PB83-258376

Benefits Analysis of Alternative Secondary National Ambient Air Quality Standards for Sulfur Dioxide and Total Suspended Particulates. Volume 5

Mathtech, Inc., Princeton, NJ

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Aug 82

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
450/5-83-001 E		PB83 258376

4. TITLE AND SUBTITLE	5. REPORT DATE
Benefit Analysis of Alternative Secondary National Ambient Air Quality Standards for Sulfur Dioxide and Total Suspended Particulates	August 1982
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Ernest H. Manuel, Jr. Kathleen M. Brennan Robert L. Horst, Jr.	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Mathtech, Inc. P.O. Box 2392 Princeton, NJ 08540	10. PROGRAM ELEMENT NO. DU11A2A
	11. CONTRACT/GRANT NO. 68-02-3392
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED Final Report
	14. SPONSORING AGENCY CODE OAQPS

15. SUPPLEMENTARY NOTES

Project Officer: Allen C. Basala

16. ABSTRACT

This study was initiated by EPA's Office of Air Quality Planning and Standards as part of its review of the current secondary standards for sulfur dioxide (SO_2) and total suspended particulates (TSP). The study has drawn heavily upon new data and research advances from the past decade or so, and considerably expands the information available about the economic benefits of selected air pollution control regulations.

The theoretical base for the analysis is a series of models structured to simulate optimizing behavior by members of society in markets where air quality has an influence. Groups of these members of society are referred to as "economic sectors." The four sectors analyzed in this study are: 1) Household, 2) Agricultural, 3) Manufacturing, and 4) Electric Utilities.

Consideration of optimizing behavior allows for the possibility of differing responses to air pollution. This reduces the potential for biased estimates and also allows inferences consistent with the willingness-to-pay criterion.

Benefits were calculated for the current and an alternative (24-hour averaging time) SO_2 secondary standard and for the current TSP secondary standard. Subsequent to a public peer review meeting, additional analyses were undertaken to assess the validity of the benefit estimates.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Economic Sectors Benefits Analyses Optimizing Behavior Secondary National Ambient Air Quality Standards Air Pollution, SO_2 and TSP	> This document discusses a limited extrapolation of the results of the benefit analysis.	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	Unclassified	75
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB83-258376

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/5-83-001e
August 1982

Air

EPA

Benefit Analysis of Alternative Secondary National Ambient Air Quality Standards for Sulfur Dioxide and Total Suspended Particulates

Volume V

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

FINAL ANALYSIS

BENEFITS ANALYSIS OF ALTERNATIVE SECONDARY NATIONAL AMBIENT AIR QUALITY STANDARDS FOR SULFUR DIOXIDE AND TOTAL SUSPENDED PARTICULATES

VOLUME V

Benefits Analysis Program
Economic Analysis Branch
Strategies and Air Standards Division
Office of Air Quality Planning and Standards

U.S. Environmental Protection Agency

Research Triangle Park
North Carolina 27711

August 1982

FINAL ANALYSIS

BENEFITS ANALYSIS OF ALTERNATIVE SECONDARY NATIONAL AMBIENT AIR QUALITY STANDARDS FOR SULFUR DIOXIDE AND TOTAL SUSPENDED PARTICULATES

By:

Ernest H. Manuel, Jr.
Robert L. Horst, Jr.
Kathleen M. Brennan
William N. Lanen
Marcus C. Duff
Judith K. Tapiero

With the Assistance of:

Richard M. Adams
David S. Brookshire
Thomas D. Crocker
Ralph C. d'Arge
A. Myrick Freeman, III
Shelby D. Gerking
Edwin S. Mills
William D. Schulze

MATHTECH, Inc.
P.O. Box 2392
Princeton, New Jersey 08540

EPA Contract Number 68-02-3392

Project Officer:
Allen C. Basala
Economic Analysis Branch
Strategies and Air Standards Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

August 1982

PREFACE

This report was prepared for the U.S. Environmental Protection Agency by MATHTECH, Inc. The report is organized into six volumes containing a total of 14 sections as follows:

Volume I

- Section 1: Executive Summary
- Section 2: Theory, Methods and Organization
- Section 3: Air Quality and Meteorological Data

Volume II

- Section 4: Household Sector
- Section 5: Residential Property Market
- Section 6: Labor Services Market

Volume III

- Section 7: Manufacturing Sector
- Section 8: Electric Utility Sector

Volume IV

- Section 9: Agricultural Sector

Volume V

- Section 10: Extrapolations
- Section 11: Bibliography

Volume VI

- Section 12: Summary of the Public Meeting
- Section 13: Analysis of Pollutant Correlations
- Section 14: Summary of Manufacturing Sector Review

The analysis and conclusions presented in this report are those of the authors and should not be interpreted as necessarily reflecting the official policies of the U.S. Environmental Protection Agency.

ACKNOWLEDGMENTS

This report and the underlying analyses profited considerably from the efforts of Allen Basala, who served as EPA Project Officer, and V. Kerry Smith, who served as a reviewer for EPA. Allen provided the initiative and on-going support to conduct an applied benefits analysis. Kerry's technical insights and suggestions are reflected in nearly every section of the report.

James Bain and Tom Walton of EPA, and Jan Laarman and Ray Palmquist, who served as reviewers for EPA, also contributed substantially to individual report sections through their advice and comments during the course of the project. Also providing helpful comments and assistance were Don Gillette, Fred Haynie, Neil Frank and Larry Zaragosa, all with EPA.

Several other members of the Mathtech staff contributed to the project during various stages of the work. They included Robert J. Anderson, Jr., Neil Swan, John Keith, Donald Wise, Yaw Ansu, Gary Labovich, and Janet Stotsky.

The production of the report was ably managed by Carol Rossell, whose patience remained intact through countless drafts and deadlines. Carol was assisted by Sally Webb, Gail Gay, and Deborah Piantoni.

Finally, we extend our appreciation to the many dozens of individuals, too numerous to list here, who provided advice, suggestions, and data during the course of the project.

CONTENTS

10. EXTRAPOLATIONS

Introduction 10-1

Household Sector Extrapolations 10-2

Overview 10-4
Data Development Procedures 10-5
Estimated Household Sector Benefits 10-7

Manufacturing Sector Extrapolations 10-13

Overview 10-13
Extrapolation Procedure 10-17
Manufacturing Sector Estimated Benefits 10-21

Electric Utility Sector Extrapolations 10-27

Overview 10-27
Other Types of Power Plants 10-27
Transmission and Distribution Systems 10-28

Summary of Extrapolations 10-34

References 10-38

11. BIBLIOGRAPHY

Part A: Economic Theory and Data 11-1

Part B: Sources of Information on Pollution 11-15

TABLES

Number		Page
10-1.	Coverage of Economic Activity in Each Sector	10-3
10-2.	Household Sector Extrapolation for Current 3-Hour Secondary SO_2 Standard	10-8
10-3.	Household Sector Extrapolation for Alternative 24-Hour Secondary SO_2 Standard	10-10
10-4.	Household Sector Extrapolation for Current 24-Hour Secondary TSP Standard	10-12
10-5.	Industries Included in the Extrapolations	10-18
10-6.	Manufacturing Sector Extrapolation for Current 3-Hour Secondary SO_2 Standard	10-22
10-7.	Manufacturing Sector Extrapolation for Alternative 24-Hour Secondary SO_2 Standard	10-23
10-8.	Manufacturing Sector Extrapolation for Current 24-Hour Secondary TSP Standard	10-24
10-9.	Geographic Distribution of Extrapolated Benefits for the Manufacturing Sector	10-26
10-10.	Estimated Benefits to Electric Utility Transmission and Distribution Systems from Attainment of the Alternative 24-Hour SO_2 Secondary Standard	10-33
10-11.	Estimated Benefits in Sectors Analyzed for Current SO_2 Secondary Standard	10-35
10-12.	Estimated Benefits in Sectors Analyzed for Alternative SO_2 Secondary Standard	10-36
10-13.	Estimated Benefits in Sectors Analyzed for Current TSP Secondary Standard	10-37

SECTION 10

EXTRAPOLATIONS

SECTION 10

EXTRAPOLATIONS*

INTRODUCTION

The previous sections of this report have estimated the economic benefits of alternative secondary ambient air quality standards for the household, manufacturing, electric utility, and agricultural sectors. However, the estimates obtained in each of the sectors represent only a partial accounting of total benefits. In each of the analyses, data limitations or methodological considerations prevented the enumeration of a complete set of national benefits. For example, in the household sector, the geographic coverage was limited to 24 SMSAs and economic data were available for only about 40 percent of current consumption expenditures. Similarly, the analysis in the manufacturing sector covered only six industries, with these industries accounting for about 8 percent of the value added in that sector. In order to broaden the scope of the analysis, this section provides a limited extrapolation of the results of the basic analysis.

---

* Sections 1 and 2 of the report should be read before tnis section. An understanding of Sections 3, 4, 7 and 8 would also be desirable, but it is not as essential.

Table 10-1 summarizes the basic scope of the study. Note that in addition to limited coverage of the sectors analyzed in this study, there are several sectors which were not covered at all. Furthermore, consideration of benefit types is restricted to vegetation and materials damage and soiling. Since the extrapolations reported in this section are limited to extended coverage of the sectors and benefit types analyzed in the basic study, the benefits reported represent conservative estimates of the benefits associated with attainment of the secondary ambient air quality standards.

The remaining subsections review the extrapolation procedures and report extrapolated benefits for the household, manufacturing, and electric utility sectors. For reasons given in Section 9, no extrapolations were attempted in the agricultural sector.

HOUSEHOLD SECTOR EXTRAPOLATIONS

The basic analysis in the household sector is limited to 24 SMSAs, with these SMSAs accounting for approximately 30 percent of the total U.S. population in 1976. This subsection estimates the benefits that would be realized by other areas of the country, given attainment of the secondary standards for TSP and SO_2.

TABLE 10-1. COVERAGE OF ECONOMIC ACTIVITY IN EACH SECTOR

Final demand sector	Percent of final demand	Percent coverage	
		Basic analysis	Basic plus extrapolation
Households*	63.5	17	45-55
Government	20.5	0	0
Other	16.0	0	0
Totals	100.0	11**	29-35**

Producing sector	Percent of GNP	Percent coverage	
		Basic analysis	Basic plus extrapolation
Agriculture, forestry and fisheries	3.1	2-15	2-15
Mining and construction	7.1	0	0
Manufacturing	23.9	4-8	25-30
Transportation, communication and utilities	9.0	8-11	15-20
Commercial and services	43.6	0	0
Government and other	13.3	0	0
Totals	100.0	2-3**	7-9**

* Goods and services consumed by individuals and certain nonprofit institutions. Includes rental of dwellings but not purchases of dwellings. The latter are included with "other".

** Weighted average coverage.

Source: Estimates of final demand and GNP shares are from U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. July 1979. Tables 1.1 and 6.1.

Overview

In the basic household sector analysis (see Section 4), benefits are calculated in a two-stage procedure. In the first stage, price data for marketed goods such as laundry and cleaning supplies, together with data on air quality, climate, and household demographics, are used to calculate the implicit prices for "final" goods and services such as "household operations." In the second stage, the implicit prices are used to calculate the allocation of household expenditures among the various final goods and services. In this formulation, the effect of an air quality improvement is to reduce some of the implicit prices and therefore induce a reallocation of household expenditures. Benefits are then estimated by calculating the compensating variation (CV) associated with the expenditure reallocation.*

In extrapolating beyond the original 24 SMSAs, the same procedure as described above is used. However, some of the required demographic, climate, and market price data are not available for the counties outside of the original SMSAs. Thus, approximate data are used instead, together with actual air quality data. For the demographic and climate data, regional averages are used. For the

---

* The compensating variation (CV) is a measure of the compensation required such that the consumer is indifferent between the original price set and the new price set.

price data, two alternative approaches are used since benefits are especially sensitive to price: regional average prices, and the highest and lowest price sets from among the original SMSAs (where high and low are measured in terms of effect on benefits). The specific data development procedures are described more fully below.

Note that this extrapolation procedure assumes that the implicit price and expenditure models developed in the basic analysis are also appropriate for other parts of the country. This does not seem unreasonable since the original 24 SMSAs were quite varied. Note also, however, that by using the models developed in the basic analysis, the scope of the extrapolation is limited to those benefit types included in that analysis. Consequently, since such benefits as visibility improvement and ecosystem protection were neglected there, the extrapolated benefits in the household sector continue to represent conservative estimates of the benefits associated with attainment of the secondary standards.

Data Development Procedures

The geographic extrapolations reported here are done on a county-by-county basis. Counties included within the boundaries of the original 24 SMSAs were excluded from the extrapolation procedures. The specific assumptions made in performing the extrapolation include:

- Certain data are assigned to counties based on the region in which the county is located. In particular, the following steps were taken:

  — The country is divided into two major areas -- Northeast plus North Central and South plus West.

  — Averages by region are computed from the SMSA-specific data for the following items:

    a) 30-year average temperature.

    b) family size

    c) average annual percent change in the all-item consumer price index.

    d) average percent of total consumption expenditures in the SMSA data.

    e) disaggregate and aggregate price sets developed for the basic analysis.

- Certain data are assigned to counties based on county- or state-level data. These data include:

  — Air quality data obtained from the SAROAD data base (1978 statistics) on a site-by-site basis and aggregated to the county-level by the procedures described in Section 3.

  — Baseline county population numbers obtained from the County and City Data Book, 1977 (1). These are 1975 statistics. Conversions to household data are made by dividing by the regional family size values.

  — Population projections by county developed by calculating the annual percent change in population by county between 1970 and 1975. These data are obtained from the County and City Data Book, 1977 (1). The annual changes are assumed to be maintained at the same rate into the future.

  — State income projections for 1985 and 1990 (current 1972 dollars) obtained from the Department of Commerce News, December 9, 1980 (2).

  — The annual percent changes in income implied by the data described above are computed for each state. These annual changes are assumed to hold into the future.

- Certain data or assumptions are pertinent to all counties. These include:
  - The parameters of the various demand equations estimated in Section 4.
  - The air quality scenario developed for the benefits calculations remains the same as before.
  - Benefits are calculated as discounted present values in 1980, in 1980 dollars. A social rate of discount of 10 percent and an infinite time horizon are assumed.

Estimated Household Sector Benefits

Given the extrapolation scenario described above, household sector benefits were calculated on a county-by-county basis for each pollutant and then aggregated to Census Divisions.

Table 10-2 presents the benefits obtained in the household sector for attainment of the current 3-hour secondary standard for SO_2. As described in Section 3, it is not possible to calculate directly the incremental benefits for the 3-hour standard since there is no primary standard defined for the same averaging time. Consequently, for each county, we have calculated the equivalent 24-hour concentration level that would be expected to occur when the 3-hour standard is just met. This 24-hour concentration level is then used as an "equivalent" secondary standard and comparisons can be made directly with the current 24-hour second-high primary standard.

TABLE 10-2. HOUSEHOLD SECTOR EXTRAPOLATION FOR CURRENT 3-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Census Division	Benefit estimates with average price set
1. New England	--
2. Mid-Atlantic	--
3. East North Central	1.81
4. West North Central	--
5. South Atlantic	--
6. East South Central	0.02
7. West South Central	--
8. Mountain	0.19
9. Pacific	--
U.S. total	2.02

* Current SO_2 secondary standard is 1,300 $\mu g/m^3$, based on a 3-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

-- Equals zero.

As Table 10-2 shows, the estimated benefits of the current 3-hour SO_2 standard are small. This is in part because only soiling and materials effects are captured by the model. It also occurs because very few counties in the United States are out of compliance with the equivalent secondary standard, given that the primary standard is

attained. In fact, benefits for attainment of the secondary standard are predicted to be realized in only five counties, with total benefits of $2.02 million dollars.

In Section 3, it was noted that air pollution measures based on longer averaging times were likely to be more appropriate for the types of damaging effects included in our analysis. Because of this, benefits were analyzed for an alternative secondary standard for SO_2 based on a 24-hour averaging time. For this alternative standard of 260 $\mu g/m^3$ the SO_2 benefits are as shown in Table 10-3.

The top part of Table 10-3 reports benefits only for counties not included in the original analysis. The range of estimates denoted by low, average, and high price sets gives some idea of the sensitivity of the results to assumptions concerning the assignment of prices to counties.

The average price set is defined on a regional basis. That is, from the original group of 24 SMSAs, average prices are calculated for all those SMSAs in the Northeast or North Central regions to obtain an index of prices for all counties located in these two regions. A similar average is calculated for counties in the South and West.

The low and high price sets are obtained by finding the SMSAs, from our group of 24, that yield the low and high marginal valuations of air quality improvements. For example, in order to identify the

TABLE 10-3. HOUSEHOLD SECTOR EXTRAPOLATION FOR ALTERNATIVE 24-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Census Division	Low price set	Average price set	High price set
1. New England	6	6	8
2. Mid-Atlantic	24	26	33
3. East North Central	64	69	87
4. West North Central	1	1	1
5. South Atlantic	43	41	62
6. East South Central	21	20	31
7. West South Central	--	--	--
8. Mountain	19	18	28
9. Pacific	--	--	--
Extrapolated U.S. total	178	181	250
24 SMSA total		920	
Total U.S. benefits		1,101	

* Alternate SO_2 secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

-- Equals zero.

"high price set" SMSA, we evaluate the predicted level of benefits per unit change in air quality (TSP and SO_2) for each SMSA. This evaluation is performed at a variety of air quality levels in order to

account for changes in the marginal valuations across concentration levels. When this analysis is performed, New York City households are found to have the highest per-unit valuation. Thus, the price set for New York City is assigned to each of the counties in the extrapolation, and the benefits calculations performed. These results are reported under the high price set column. Similar steps are carried out to identify the low price set SMSA. In this case, Atlanta is found to be the SMSA with the lowest marginal valuations.

On a regional basis, the largest benefits are realized in the eastern part of the country, with the East North Central Region accounting for almost 40 percent of extrapolated U.S. benefits.

The bottom part of Table 10-3 lists the total benefits estimated for the original SMSAs. Because of the different types of sensitivity checks carried out in the two sets of benefits calculations, only the "most reasonable" values are reported from the analysis phase. These are listed under the average price set column, and the estimate of total U.S. benefits for SO_2 is recorded on the last line of the table. The best estimate of total household sector benefits (soiling and materials benefits) for attainment of a 24-hour averaging time secondary standard for SO_2 is approximately $1.1 billion.

Table 10-4 presents extrapolations for TSP. The low, average, and high price sets are as defined above. Since primary and secondary air quality standards for TSP exist with the same averaging time, no

TABLE 10-4. HOUSEHOLD SECTOR EXTRAPOLATION FOR CURRENT 24-HOUR SECONDARY TSP STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Census Division	Low price set	Average price set	High price set
1. New England	64	72	86
2. Mid-Atlantic	119	133	160
3. East North Central	220	245	294
4. West North Central	60	68	80
5. South Atlantic	58	63	73
6. East South Central	64	69	79
7. West South Central	60	67	77
8. Mountain	244	270	308
9. Pacific	297	344	392
Extrapolated U.S. total	1,186	1,331	1,549
24 SMSA total		2,299	
Total U.S. benefits		3,630	

* Current TSP secondary standard is 150 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

additional transformations were required to account for alternate averaging times.

The regional dispersion of TSP benefits is different from that observed for SO_2. In this case, the largest benefits occur in the

East North Central, Mountain, and Pacific regions. Note, however, that the other six regions realize nontrivial benefits.

As with SO_2, the bottom part of Table 10-4 records the benefits calculated from the original 24 SMSAs. In this case, the best estimate of total household sector benefits (soiling and materials benefits) for attainment of a 24-hour averaging time secondary standard for TSP is about $3.63 billion.

MANUFACTURING SECTOR EXTRAPOLATIONS

Overview

The basic analysis in the manufacturing sector (see Section 7) is limited to six 3-digit SIC industries comprising about 8.3 percent of the value added in the manufacturing sector. The analysis is done on a county-by-county basis in each industry. The unavailability of air quality data and economic data for those industries in many counties of the U.S. further reduces the coverage to about 3.6 percent (i.e., data sets were available for counties containing about one-half the economic value in the six industries). The possibilities for extrapolation of the basic analysis thus included: (1) extending the geographic coverage of the original six industries to other areas of the country; and (2) extending coverage to other manufacturing industries.

Geographic Extrapolation--

It was decided not to undertake the geographic extrapolation for two reasons. First, although counties containing only half of the economic value (on average) in the six industries were included in the basic analysis, these counties are the more industrialized counties in the U.S. Since air pollution is likely to be more severe in these counties, and less severe in the other counties, the probability of identifying large additional benefits in the other counties was judged to be small.

Second, the basic analysis already included all counties for which economic data were available. Thus, to extend the geographic coverage to other areas, the analysis would have to be done at the more aggregate SMSA (metropolitan area) level. A review of this situation indicated the following: (1) single-county SMSAs would be of no interest because those for which economic data were available were already included in the basis analysis; and (2) for many of the multi-county SMSAs, air quality data were not available for all of the member counties, and thus air quality for the SMSA was not well defined.

In view of the two reasons above -- the expectation of small benefits, and the limitations of the air quality data -- no geographic extrapolation for the original six industries was undertaken.

Industry Extrapolation--

The alternative possibility was to extrapolate the results for the original six industries to some of the other closely related manufacturing industries. For example, two of the industries included in the basic analysis were SIC 344 (fabricated structural metal products) and SIC 346 (metal forgings and stampings). Both of these 3-digit SIC industries are part of the broader 2-digit industry, SIC 34 (fabricated metal products). One might therefore take the view that the air pollution effects identified in the two subindustries are representative of the effects likely to be present in the broader industry group.

The extrapolation to other industries, of course, raises two questions. First, can the effects identified in the subindustries be viewed as representative of the effects in the broader industry group? Second, if so, how should the extrapolation be carried out? The first question cannot be answered definitively without actually conducting a specific analysis of the other subindustries in each group. Clearly, there are similarities among the various 3-digit industries within a 2-digit group. The similarities can include the use of common raw materials, similar processing techniques, and most importantly, the production of related end products. However, the industries can also be different in important ways, and it is the latter fact which guided the selection of an extrapolation procedure.

One possible extrapolation procedure would be to apply the estimated models for the six industries, developed in Section 7, to data for the corresponding 2-digit industries. The models in that section are designed to estimate the savings in production cost (e.g., maintenance cost) due to an improvement in air quality. However, direct application of the models was viewed as unattractive for two reasons. First, it requires two specific assumptions: (1) that the underlying production technology is the same at both the 2-digit and 3-digit levels; and (2) that the effect of air pollution on that technology is similar at both the 2-digit and 3-digit levels. Comparisons in Section 7 between the 3-digit SIC models developed in this study and the 2-digit SIC models developed in another study suggest that at least the first of these assumptions may not always be valid.

A second problem with applying the models directly is that the models incorporate specially developed price indexes for raw materials inputs used by the 3-digit industries. New price indexes would be required corresponding to the different mix of input materials used by the 2-digit industries.

In view of the above, a less formal extrapolation procedure was adopted. It basically involves answering the following question: If the benefits of improved air quality at the 2-digit level were the same as at the 3-digit level in terms of the percentage savings in production cost for a given change in air quality, how large would the

benefits be? Note that this approach does not necessarily require that the underlying production technologies be the same -- only that air quality benefits, on a percentage basis, be the same. The remainder of this subsection addresses the above question. Three features of the extrapolation are worth noting:

- Actual economic data on each 2-digit industry are used, on a county-by-county basis.
- Actual air quality data are used on a county-by-county basis.
- The sensitivity of the results to variations in the benefits observed within each 3-digit industry are examined.

The extrapolations are carried out for the 2-digit SIC industries listed in Table 10-5.

Extrapolation Procedure

In the basic analysis, benefits are calculated by estimating the savings in production costs that would result from attainment of the secondary ambient air quality standards, as compared to attainment of the primary standards only. This savings (benefit) is calculated for each industry and county. It is calculated as the discounted present value (DPV) in 1980 dollars, of all future cost savings due to the secondary standards.

TABLE 10-5. INDUSTRIES INCLUDED IN THE EXTRAPOLATIONS

Industry			Basis for the extrapolation		
SIC code	Name	Value added*	SIC code	Name	Value added*
20	Food and kindred products	35.6	201	Meat products	5.0
			202	Dairy products	4.1
26	Paper and allied products	13.1	265	Paperboard containers and boxes	3.6
34	Fabricated metal products	26.9	344	Fabricated structural metal products	6.7
			346	Metal forgings and stampings	5.1
35	Machinery, except electrical	37.6	354	Metalworking machinery	4.9

* Billions of 1972 dollars.

Source: U.S. Bureau of the Census. Census of Manufactures - 1972. 1976.

The benefits calculated in the basic analysis are used in the extrapolations as follows. First, the following quantities are calculated for each county included in the basic analysis for each 3-digit SIC:

- The dollar benefits, per dollar of value added, per unit change in air quality.
- The dollar benefits, per dollar of value shipped, per unit change in air quality.

For convenience, the first quantity above will be denoted by BVA_{ij}, where i indexes industries and j indexes counties. The second quantity will be denoted as BVS_{ij}. The above ratios are calculated for each county where there are non-zero benefits; i.e., where air quality is assumed to change as a result of the standard.

As an example, suppose the 1980 discounted present value of all future benefits in industry i and county j is $1 million, the 1972 (base year) value added in the corresponding industry and county is $10 million, and the air quality change due to the secondary standard is 50 $\mu g/m^3$ measured as a 24-hour average. In this case

$$BVA_{ij} = (1)/(10)/(50) = 0.002$$

Calculations are made for both value added and value of shipments since both are alternative measures of economic activity, and thus alternative bases for extrapolation.

As a result of the above calculations, six ratios are developed for each 3-digit industry: the minimum, maximum, and average values of BVA_{ij}, over all counties, and the corresponding ratios for BVS_{ij}. The minimums and maximums are calculated, as well as the averages, in order to assess the sensitivity of the estimates.

The second step in the extrapolation procedure was to assemble data on the value added and value of shipments in each county for each of the four 2-digit industries. Data for 1972 were used in order to provide consistent scaling with the ratios above. Note that with the use of the more aggregate 2-digit industries, data are available for more counties than in the basic analysis based on 3-digit industries. Hence, the industry extrapolation also accomplishes some geographic extrapolation of the basic analysis.

Also collected for each county was the air quality data for SO_2 and TSP in 1978. As in the basic analysis, data for 1978 were used as the base year in describing the scenario for attainment of the secondary standard (see Section 7).

The third step in the calculation was to multiply the ratios by the appropriate measures of economic value and air quality change in each county. This leads to six county-by-county estimates of the discounted present value of benefits in each industry -- six corresponding to the six different ratios.

In the two 2-digit industries where more than one 3-digit industry was available as the basis for extrapolation (SICs 20 and 34), a weighted average of the benefits for each 3-digit industry was used in estimating the benefits for the corresponding 2-digit industry. The weights used were value added or value of shipments, depending on which ratio was under consideration. In SIC 201, air pollution effects were not statistically significant at the 10 percent level (see Section 7). Thus, in SIC 20, a weighted average of zero and SIC 202 benefits was used. In SIC 344, air pollution effects were occasionally significant but not in the final model (nor at all in SIC 346). The calculation for SIC 34 is based on a weighted average of zero and SIC 344 benefits, but in intended to be primarily illustrative.

Manufacturing Sector Estimated Benefits

When the county-by-county benefits, calculated as described above, are added up, the national estimates shown in Tables 10-6 through 10-8 result. Table 10-6 presents estimates for the current 3-hour SO_2 secondary standard. Table 10-7 contains estimates for the alternative 24-hour SO_2 secondary standard. Estimates for the current 24-hour TSP secondary standard are in Table 10-8. In each table, estimates are shown for each of the six ratios -- the minimum, maximum, and average ratio based on value added, and similarly for value of shipments. All estimates are 1980 discounted present values, in 1980 dollars, using a 10 percent discount rate. Note that the

TABLE 10-6. MANUFACTURING SECTOR EXTRAPOLATION FOR CURRENT 3-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in million of 1980 dollars)**

SIC	Basis for extrapolation					
	Value added			Value of shipments		
	Minimum ratio	Average ratio	Maximum ratio	Minimum ratio	Average ratio	Maximum ratio
20	7.3	11.1	25.6	6.1	6.4	6.7
26	—	—	—	—	—	—
34	—	—	—	—	—	—
35	—	—	—	—	—	—

* Current SO_2 secondary standard is 1,300 $\mu g/m^3$, based on a 3-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

— Equals zero.

TABLE 10-7. MANUFACTURING SECTOR EXTRAPOLATION FOR ALTERNATIVE 24-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in million of 1980 dollars)**

SIC	Basis for extrapolation					
	Value added			Value of shipments		
	Minimum ratio	Average ratio	Maximum ratio	Minimum ratio	Average ratio	Maximum ratio
20	1,860	2,820	6,537	1,479	1,558	1,622
26	307	343	393	314	354	393
34	—	—	—	—	—	—
35	—	—	—	—	—	—

* Alternate SO_2 secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

— Equals zero.

TABLE 10-8. MANUFACTURING SECTOR EXTRAPOLATION FOR CURRENT 24-HOUR SECONDARY TSP STANDARD* (discounted present values for 1980 in million of 1980 dollars)**

SIC	Basis for extrapolation					
	Value added			Value of shipments		
	Minimum ratio	Average ratio	Maximum ratio	Minimum ratio	Average ratio	Maximum ratio
20	--	--	--	--	--	--
26	--	--	--	--	--	--
34+	6,511	10,148	19,051	7,156	9,307	11,495
35	2,707	6,788	10,253	3,539	8,029	11,798

* Current TSP secondary standard is 150 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

+ Illustrative calculations based on SIC 344 benefits.

-- Equals zero.

estimates are inclusive of the benefits for the six 3-digit industries.

As shown in Table 10-6, benefits for the current 3-hour SO_2 secondary standard are predicted to arise in only one industry, SIC 20, and be very small. This is because so few counties are out of compliance with this standard. It is for this same reason that no benefits are predicted to arise in SIC 26. For SICs 34 and 35 the

effect of SO_2 was not found to be statistically significant in the basic analysis (for SICs 344, 346, and 354) and thus no benefits are estimated.

In Table 10-7, estimated benefits for the alternative 24-hour SO_2 standard are presented. In this case, because many more counties are out of compliance, benefits are considerably larger.

Estimated benefits for the current 24-hour TSP standard are shown in Table 10-8. In SICs 20 and 26, the effect of TSP was not found to be statistically significant in the basic analysis (for SICs 201, 202, and 265). Hence no benefits arise in these industries. Large benefits are estimated for SIC 34 and SIC 35, however. Recall that these are 1980 discounted present values over an infinite time horizon. For comparison purposes, the discounted present values of future shipments in these two industries are estimated to be approximately $1 trillion and $1.3 trillion, respectively. Thus, benefits are approximately 0.9 percent and 0.6 percent of value shipped, respectively, when estimated using the "average" ratio for value of shipments.

The geographic distribution of estimated benefits is shown in Table 10-9. Entries are included for those industries, pollutants and standards with non-zero benefits. Estimates are shown for the extrapolation based on the "average" ratio for value of shipments.

TABLE 10-9. GEOGRAPHIC DISTRIBUTION OF EXTRAPOLATED BENEFITS FOR THE MANUFACTURING SECTOR (discounted present values for 1980 in millions of 1980 dollars)*

Census division	Current 3-hour SO_2 standard	Alternate 24-hour SO_2 standard		Current 24-hour TSP standard	
	SIC 20	SIC 20	SIC 26	SIC 34**	SIC 35
New England	—	5	75	417	20
Mid-Atlantic	—	497	134	1,359	970
East North Central	6	808	134	4,654	3,755
West North Central	—	67	10	475	367
South Atlantic	—	15	—	144	15
East South Central	—	134	—	304	163
West South Central	—	--	—	452	120
Mountain	—	33	—	162	659
Pacific	—	--	—	1,341	1,959
U.S. totals	6	1,558	354	9,307	8,029

* Using a discount rate of 10 percent and the "average" ratio for value of shipments. Details may not add to totals due to independent round-off errors.

** Illustrative calculations based on SIC 344 benefits.

-- Equals zero.

ELECTRIC UTILITY SECTOR EXTRAPOLATIONS

Overview

The basic analysis for the electric utility sector (see Section 8) was concerned with the effects of air pollution (e.g., corrosion) on the maintenance and operating costs for privately-owned, fossil fuel-fired, steam-electric generating plants. Not considered in that analysis were the effects on other types of generating plants, or on transmission and distribution systems. These other effects are considered in this section.

Other Types of Power Plants

The basic analysis found that fossil steam-electric power plants in polluted areas experience higher maintenance costs than power plants in cleaner areas, after statistically controlling for other sources of cost variation. This effect was associated with SO_2 pollution but not TSP.

Based on the above finding, the benefits of attaining compliance with the alternative 24-hour SO_2 secondary standard were estimated.* Benefits totaling $55.8 million, in the form of cost savings for fossil steam-electric plants, were identified in 22 counties. This

---

* No benefits were found for the current 3-hour SO_2 secondary standard.

figure is the 1980 discounted present value of all future benefits, at a 10 percent discount rate.

In the above counties, fossil steam-electric power plants accounted for 79 percent of the installed generating capacity. Within these counties there were also gas turbine, hydroelectric, and gas/steam turbine plants. A detailed analysis of the maintenance costs of these other plants was not undertaken, in view of the fact that the additional benefits to these plants were likely to be small. Instead, the following rough calculation was made.

If we assume that the total benefits in these counties are proportional to installed capacity (i.e., benefits to other generating plants are comparable to those for fossil steam plants), then the additional benefits to the other plants can be calculated as

$$55.8/0.8 - 55.8 = \$14.0 \text{ million.}$$

Note that this is based on a rather strong assumption, but in view of the small magnitude, a more specific analysis did not seem warranted.

Transmission and Distribution Systems

As noted in Sections 2 and 8, data limitations make a statistical analysis of air pollution effects on transmission and distribution systems difficult. Individual system components, such as transmission

towers, can and have been studied statistically (see Section 8 for references). However, the overall systems are for the most part so geographically dispersed that the appropriate matching with air quality data is not well-defined.

As an alternative basis for estimating benefits, an updated version of the approach and data developed by Perl (3) was used. The approach involves the following steps:

i) Estimate the inventory for key elements of the transmission and distribution system in some base year.

ii) Adjust the baseline inventory to account for growth after the base year.

iii) Allocate the adjusted inventory among counties based on the distribution of population.

iv) Estimate the additional unit maintenance cost as a function of air pollution conditions.

v) Calculate benefits as the savings in maintenance cost in each county, based on the change in air quality as a result of achieving the secondary standard.

Each of these steps is described below.

Baseline Inventory—

Among the items considered in the study by Perl were three of interest for the electric utility sector analysis. These included: (1) externally mounted power transformers, (2) galvanized steel power line transmission towers, and (3) pole line hardware. Note that the

latter are also used jointly by the telephone utilities so an adjustment for this fact is made later in the analysis. Note also that some electricity customers may own substation equipment, and thus external power transformers. However, utility ownership is far more common, so the possibility of customer ownership is neglected in the analysis.

The baseline inventory for the above items in 1970 were estimated by Fink et al. (4) to have been as follows:

- Transformers -- $556.63 \cdot 10^6$ ft^2
- Towers -- 194,000 towers $\cdot$ 2,500 ft^2/tower $= 485 \cdot 10^6$ ft^2
- Hardware — $3.04 \cdot 10^6$ tons $\cdot$ 450 ft^2/ton $= 1,368 \cdot 10^6$ ft^2

Growth Adjusted Inventory—

In the Perl study, benefits were calculated for 1978 and the growth in inventory between 1970 and 1978 was assumed to be at the same rate as the growth in GNP. In this study, an estimate for 1985 is required, and the inventory growth is taken to be at the same rate as the growth in installed electric generating capacity as forecasted by the Department of Energy (5). The latter should be a better indicator of the requirements for transmission and distribution facilities. This assumption leads to adjusted inventory estimates (in ft^2) of $1,120 \cdot 10^6$, $976 \cdot 10^6$, and $2,752 \cdot 10^6$, respectively.

Geographic Allocation--

As in the Perl study, we assumed that the inventory was distributed in the same manner as the population distribution. The population distribution by county in 1975 was used, as reported in the County and City Data Book (1).

Incremental Maintenance Cost--

As in the Perl study, estimates of the additional maintenance cost due to pollution were taken from Fink et al. (4). In 1970 dollars, these were

- Transformers -- \$0.0167 per ft^2 per year.
- Towers -- \$0.0233 per ft^2 per year.
- Hardware -- \$1.20 per pole per year/4 ft^2 per pole = \$0.30 per ft^2 per year.

Since poles are often jointly used by both telephone and electric utilities, we assume that half of the pole line hardware maintenance cost is incurred by each, thus yielding \$0.15 per ft^2 per year. To be consistent with other parts of this study, the above costs were then adjusted to 1980 dollars using the implicit price deflator for GNP.

The estimates above represent the difference in maintenance cost between "clean" and "polluted" environments, neither of which was defined in the original study by Fink. Perl converted the estimates to cost per unit of SO_4 pollution. In this study, the conversion is made to costs per unit of SO_2 pollution. As the definition of

"polluted", we used the population weighted average SO_2 concentration in all of the counties which exceeded the primary 24-hour SO_2 standard in 1978. The weighted average was 555.64 $\mu g/m^3$. As the definition for "clean", we used the alternative 24-hour SO_2 secondary standard of 260 $\mu g/m^3$.

Incorporating all of the above adjustments leads to the following estimates of incremental unit maintenance costs for electric utilities in 1980 dollars (expressed in mills):

- Transformers — 0.10966 per ft^2 per year per $\mu g/m^3$.
- Towers — 0.15299 per ft^2 per year per $\mu g/m^3$.
- Hardware — 0.98498 per ft^2 per year per $\mu g/m^3$.

Estimated Benefits--

Using the above information, and actual air quality data for the individual counties, an estimate of benefits was calculated. For the 24-hour equivalent of the current 3-hour SO_2 secondary standard, the estimated benefits were $0.057 million, all in one county in the Mountain Census Division. For the alternative 24-hour SO_2 secondary standard, the estimated benefits were $54.2 million. Both of these estimates are the 1980 discounted present values of all future savings, in 1980 dollars, using a 10 percent discount rate and the attainment scenario described in earlier sections.

The above figures are conservative estimates because they assume no additional growth in the inventory after 1985. If, instead, the inventory is assumed to continue to grow at the post-1985 forecasted rate of growth in installed generating capacity reported in Reference (5), benefits for the alternative 24-hour standard would be about 40 to 50 percent higher.

The geographic distribution of benefits is shown in Table 10-10. As in the other sectors, benefits for SO_2 are heavily concentrated in the Mid-Atlantic and East North Central Divisions. This reflects both the distribution of air pollution and population.

TABLE 10-10. ESTIMATED BENEFITS TO ELECTRIC UTILITY TRANSMISSION AND DISTRIBUTION SYSTEMS FROM ATTAINMENT OF THE ALTERNATIVE 24-HOUR SO_2 SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

New England	1.4	East South Central	0.4
Mid-Atlantic	15.0	West South Central	--
East North Central	23.4	Mountain	4.9
West North Central	2.2	Pacific	—
South Atlantic	7.0	U.S. total	54.2

* Alternative SO_2 secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

— Equals zero.

SUMMARY OF EXTRAPOLATIONS

The purpose of this section has been to expand the coverage of the basic analysis. The basic analysis considered only four sectors -- households, agriculture, manufacturing, and electric utilities -- and provided only partial coverage of those sectors. In this section, the coverage was broadened by making limited extrapolations within the sectors included in the basic analysis.

In the household sector, the basic analysis covered 24 major metropolitan areas. The extrapolations extended these results to other areas of the country.

In the manufacturing sector, the basic analysis included six industries representing 8 percent of the manufacturing sector. Extrapolations were made to closely related industries, thus extending coverage to about 32 percent of the sector.

The electric utility sector basic analysis considered the effects on fossil steam-electric generation. These results were extended to other forms of generation. Additional data and procedures led to estimates for the transmission and distribution phases of the industry.

For reasons described in Section 9, no extrapolations were developed for the agricultural sector.

A summary of the results for the basic analysis and the extrapolations is provided in Tables 10-11 through 10-13. Table 10-11 includes benefits estimates for the 24-hour equivalent of the current 3-hour secondary SO_2 standard. Table 10-12 presents benefits for an alternative 24-hour secondary SO_2 standard. Table 10-13 provides the estimated benefits for the current 24-hour secondary TSP standard.

TABLE 10-11. ESTIMATED BENEFITS IN SECTORS ANALYZED FOR CURRENT SO_2 SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Sector	Basic analysis+	Basic analysis with extrapolation
Households	—	4.6
Agricultural	0.2	0.2
Manufacturing	—	6.4
Electric Utilities	—	0.1

* Current secondary standard for SO_2 is 1,300 $\mu g/m^3$, based on a 3-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

\+ Estimates shown are for effects which were statistically significant at the 10 percent level or less. Estimates would be larger if higher significance levels are used.

— Equals zero.

TABLE 10-12. ESTIMATED BENEFITS IN SECTORS ANALYZED FOR ALTERNATIVE SO_2 SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Sector	Basic analysis+	Basic analysis with extrapolations
Household	733	1,140
Agricultural	22	22
Manufacturing	345	1,912
Electric utilities	56	124

* Alternate secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

+ Estimates shown are for effects which were statistically significant at the 10 percent level or less. Estimates would be larger if higher significance levels are used.

TABLE 10-13. ESTIMATED BENEFITS IN SECTORS ANALYZED FOR CURRENT TSP SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Sector	Basic analysis+	Basic analysis with extrapolations
Household	1,144	2,930
Agricultural	—	—
Manufacturing	4,117	15,870
Electric utilities	—	—

* Current TSP secondary standard is 150 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

+ Estimates shown are for effects which were statistically significant at the 10 percent level or less. Estimates would be larger if higher significance levels are used.

— Equals zero.

REFERENCES

1. U.S. Department of Commerce, Bureau of the Census. County and City Data Book - 1977. U.S. Government Printing Office, Washington, D.C., 1978.

2. U.S. Department of Commerce, Bureau of Economic Analysis. Press release (BEA 80-74), December 9, 1980.

3. Perl, Lewis J. Alternative Estimates of the Benefits of Sulfur Dioxide Emissions Control. A report prepared for the National Commission on Air Quality, Benefit Estimation Methodology Panel. National Economic Research Associates, Inc., November 27, 1979.

4. Fink, V. W., Buttner, F. H. and W. K. Boyd. Technical Economic Evaluation of Air-Pollution Corrosion Costs on Metals in the U.S. (NTIS: PB 198-453). Battelle Memorial Institute, Columbus, Ohio, 1971.

5. Department of Energy, Energy Information Administration. Annual Report to Congress - 1980 (Volume 3: Forecasts). U.S. Government Printing Office, Washington, D.C., 1981.

SECTION 11

BIBLIOGRAPHY

BIBLIOGRAPHY — PART A

ECONOMIC THEORY AND DATA

Abbott, Michael and Orley Ashenfelter. Labour Supply, Commodity Demand and the Allocation of Time. Review of Economic Studies 43(3):389-411, October 1976.

Adams, Richard M., D.J. Menkhaus, and K.A. Keith. An Investigation of Alternative Risk Supply Models for Selected U.S. Crops. University of Wyoming, Agricultural Experiment Station, January 1981.

Allen, R.G.D. Index Numbers in Theory and Practice. London, Macmillan, 1975.

Anderson, Robert J., Jr., et al. Quantifying the Benefits to the National Economy from Secondary Applications of NASA Technology. NASA Contract NASW-2734. Princeton, Mathematica, Inc., 1975.

Anderson, Ronald W. Perfect Price Aggregation and Empirical Demand Analysis. Econometrica 47:1209-1230, 1979.

Atkinson, Scott E. and Robert Halvorsen. Interfuel Substitution in Steam Electric Power Generation. Journal of Political Economy 84:959-978, 1976.

Barten, Anton. Maximum Likelihood Estimation of a Complete System of Demand Equations. European Economic Review 1:7-73, 1969.

_____. The Systems of Consumer Demand Functions Approach: A Review. Econometrica 45:23-52, 1977.

Baumes, Harry S., Jr. and W.H. Meyers. The Crops Model: Structural Equations, Definitions, and Selected Impact Multipliers. National Economics Division, Economics, Statistics and Cooperative Service, U.S. Department of Agriculture. March 1980.

Baumol, William J. and Wallace E. Oates. The Theory of Environmental Policy. Englewood Cliffs, NJ, Prentice-Hall, 1975.

Berndt, Ernst R. and Laurits R. Christensen. The Translog Function and the Substitution of Equipment, Structures and Labor in U.S. Manufacturing, 1929-1968. Journal of Econometrics 1:81-114, 1973.

_____ and Mohammed S. Khaled. Parametric Productivity Measurement and Choice Among Flexible Functional Forms. Journal of Political Economy 87:1220-1245, 1979.

_____ and N.E. Savin. Conflict Among Criteria for Testing Hypotheses in the Multivariate Linear Regression Model. Econometrica 45(5):1263-1278, 1977.

_____ and David O. Wood. Technology, Prices, and the Derived Demand for Energy. Review of Economics and Statistics 57:259-268, 1975.

_____, Melvyn Fuss, and L. Waverman. Dynamic Adjustment Models of Industrial Energy Demand: Empirical Analysis of U.S. Manufacturing, 1947-1974. Report prepared for Electric Power Research Institute (EA-1613). Palo Alto, CA, 1980.

Becker, Gary. A Theory in the Allocation of Time. Economic Journal 75:493-517, 1965.

Blackorby, Charles, et al. Homothetic Separability and Consumer Budgeting. Econometrica 38:468-472, 1970.

_____, Daniel Primont and R. Robert Russell. Duality, Separability and Functional Structure: Theory and Economic Application. Amsterdam/New York, North Holland, 1978.

Blank, Fred, et al. Valuation of Aesthetic Preferences: A Case Study of the Economic Value of Visibility. Electric Power Research Institute, Palo Alto, CA, 1978.

Board of Governors of the Federal Reserve System. Federal Reserve Bulletin. Volume 62, 1976.

Bowden, Roger J. The Econometrics of Disequilibrium. Amsterdam/New York, North Holland, 1978.

Brookshire, David, et al. Valuing Public Goods: A Comparison of Hedonic Approaches. American Economic Review, forthcoming 1981.

Brown, A. and A. Deaton. Surveys in Applied Economics: Models of Consumer Behavior. The Economic Journal 82:1145-1236, 1972.

Brown, Charles. Equalizing Differences in the Labor Market. Quarterly Journal of Economics 94:113-134, 1980.

Brown, M. and D. Heien. The S-Branch Utility Tree: A Generalization of the Linear Expenditure System. Econometrica 40:737-747, 1972.

Caddy, Vern. Empirical Estimation of the Elasticity of Substitution. Preliminary Working Paper Number OP-09. Melbourne, Industries Assistance Commission, 1976.

Christ, Carl F., et al. Measurement in Economics: Studies in Mathematical Economics and Econometrics. Stanford, Stanford University Press, 1963.

Christensen, Laurits R. and William H. Greene. Economies of Scale in U.S. Electric Power Generation. Journal of Political Economy 84:655-676, 1976.

_____ and Marilyn Manser. Estimating U.S. Consumer Preferences for Meatwith a Flexible Utility Function. Journal of Econometrics 5:37-53, 1977.

_____ and Dale W. Jorgensen. The Measurement of U.S. Real Capital Input. 1929-1967. Review of Income and Wealth 15:293-320, 1980.

_____ and Lawrence J. Lau. Transcendental Logarithmic Production Frontiers. Review of Economics and Statistics 55:28-45, 1973.

Church, Albert M. Zoning and Vacant Land Values -- A Case Study of Albuquerque, New Mexico. Paper presented at Colloquium on Land Valuation Methods, June 1-2, 1978.

Clapp, John M. The Intrametropolitan Location of Office Activities, Journal of Regional Science 20:387-399, 1980.

Cochrane, D. and G.H. Orcutt. Application of Least Squares Regressions to Relationships Containing Autocorrelated Error Terms. Journal of the American Statistical Association 44:32-61, 1949.

Coen, Robert M. Effects of Tax Policy on Investment in Manufacturing. Papers and Proceedings of the American Economic Association 58:200-211, 1975.

Court, Louis M. Entrepreneurial and Consumer Demand Theories for Commodity Spectra. Econometrica 9(1):135-162, April 1941; 9(2):241-297, July-October 1941.

Cowing, Thomas G. The Effectiveness of Rate-of-Return Regulation: An Empirical Test Using Profit Functions, in Melvyn Fuss and Daniel McFadden (eds.) Production Economics: A Dual Approach to Theory and Applications. Vol. 2. New York, North Holland, 1978, pp. 215-246.

_____ and V. Kerry Smith. The Estimation of a Production Technology: A Survey of Econometric Analyses of Steam-Electric Generation. Land Economics 54:156-186, 1978.

_____. Manual for Computer Tape File on the Regulated Steam-Electric Power Industry 1948-1972. A report prepared for the Federal Energy Administration (CO-03-50158-00), Binghamton, NY, 1976.

_____. A Survey of Econometric Models of the Supply and Cost Structure of Electricity. A report prepared for the Electric Power Research Institute (EA-517-SR), Palo Alto, CA, 1978.

Cramer, J.S. Empirical Econometrics. Amsterdam/New York, North Holland, 1969.

Dagenais, M. The Use of Incomplete Observations in Multiple Regression Analysis. Journal of Econometrics 1:317-328, 1973.

Deaton, A. and J. Muellbauer. Economics and Consumer Behavior.

Denny, Michael and J. Douglas May. Homotheticity and Real Value-Added in Canadian Manufacturing, in Melvin Fuss and Daniel McFadden (eds.) Production Economics: A Duel Approach to Theory and Applications. Vol. 2. New York, North Holland, 1978, pp. 53-70.

Dhrymes, Phoebus J. On Devising Unbiased Estimators for the Parameters of the Cobb-Douglas Production Function. Econometrica 30:297-304, 1962.

Diewert, W.E. An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function. Journal of Political Economy 79:481-507, 1971.

_____. Exact and Superlative Index Numbers. Journal of Econometrics 4:115-145, 1976.

Downing, Paul B. Factors Affecting Commercial Land Values: An Empirical Study of Milwaukee, Wisconsin. Land Economics 49:44-56, 1973.

Fair, Ray C. The Estimation of Simultaneous Equation Models with Lagged Endogenous Variables and First Order Serially Correlated Errors. Econometrica 38:507-516, 1970.

Field, Barry C. and Charles Grebenstein. Capital-Energy Substitution in U.S. Manufacturing. Review of Economics and Statistics 62:207-212, 1980.

Fischel, W. Determinants of Voting on Environmental Quality: A Study of a New Hampshire Pulp Mill Referendum. Journal of Environmental Economics and Management 6:107-118, 1979.

Freeman, A. Myrick III. Spatial Equilibrium, the Theory of Rents, and the Measurement of Benefits from Public Programs: A Comment. Quarterly Journal of Economics 89:470-473, 1975.

Fuss, Melvyn. The Demand for Energy in Canadian Manufacturing. Journal of Econometrics 5:89-116, 1977.

_____. Factor Substitution in Electricity Generation: A Test of the Putty-Clay Hypothesis, in Melvyn Fuss and Daniel McFadden (eds.) Production Economics: A Dual Approach to Theory and Applications. Vol. 2. New York, North Holland, 1978, pp. 187-213.

_____, Daniel McFadden and Yair Mundlak. A Survey of Functional Forms in the Economic Analysis of Production, in Melvyn Fuss and Daniel McFadden (eds.) Production Economics: A Dual Approach to Theory and Applications. Vol. 1. New York, North Holland, 1978, pp. 219-268.

Gallant, A. Ronald. Testing a Subset of the Parameters of a Nonlinear Regression Model. Journal of the American Statistical Association 70:927-932, 1975.

Gardner, Bruce L. Futures Prices in Supply Analysis. American Journal of Agricultural Economics 58: 81-84, 1976.

Gertsbakh, I.B. Models of Preventive Maintenance. (Vol. 23: Studies in Mathematical and Managerial Economics.) Amsterdam/New York, North Holland, 1977.

Goldfeld, Stephen M. and Richard E. Quandt. Nonlinear Methods in Econometrics. Amsterdam/New York, North Holland, 1972.

Goodwin, Susan A. Measuring the Value of Housing Quality -- A Note. Journal of Regional Science 17:107-115, 1977.

Gorman, W. Separable Utility and Aggregation. Econometrica 27:469-481, 1959.

Grether, D.M. and Peter Mieskowski. Determinants of Real Estate Values. Journal of Urban Economics 1:127-146, 1974.

Griliches, Zvi and S. Adelman. On an Index of Quality Change. Journal of the American Statistical Association 56:535-548, 1961.

_____, ed. Price Indexes and Quality Change. Cambridge, Harvard University Press, 1971.

Hacklander, Duane. The Decade Ahead for U.S. Soybeans. In Fats and Oils Situation, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., February 1976, pp. 30-33.

Hall, Robert E. Wages, Income, and Hours of Work in the U.S. Labor Force, in G. Cain and H. Watts (eds.) Income Maintenance and Labor Supply. New York, Rand McNally, 1973.

_____ and Dale W. Jorgensen. Tax Policy and Investment Behavior. American Economic Review, 57:391-414, 1967.

Halvorsen, Robert. Energy Substitution in U.S. Manufacturing. Review of Economics and Statistics 59:381-388, 1977.

Hamermesh, D. Economic Aspects of Job Satisfaction, in O. Ashenfelter and W. Oates, (eds.) Essays in Labor Market and Population Analysis. New York, John Wiley and Sons, 1977.

Heckman, James. The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models. Annals of Economic and Social Measurement 5:475-92, 1976.

_____. Sample Selection Bias as a Specification Error. Econometrica 47:153-162, 1979.

Henderson, James M. and Richard E. Quandt. Microeconomic Theory: A Mathematical Approach. New York, McGraw-Hill, 1958.

Hildebrand, George H. and Ta-Chung Liu. Manufacturing Production Functions in the U.S., 1957. Ithaca, Cornell University School of Industrial and Labor Relations, 1965.

Hoch, I. Climate, Wages and the Quality of Life. In: Lowdon Wingo and Alan Evans (eds.) Public Economics and the Quality of Life, Baltimore, Johns Hopkins University Press, 1977.

Hoicka, John et al. Pollution Abatement and Unemployment: A Methodological Study, prepared for U.S. Environmental Protection Agency, Office of Air Programs and Office of Water Progams (NTIS PB-207 109). Washington, D.C., Institute of Public Administration, January 31, 1972.

Hori, Hajime. Revealed Preference for Public Goods. American Economic Review 65:978-91, 1975.

Horst, Robert L., Jr. Estimation of the Value of Visibility Through Application of the Expenditure Function. Unpublished Ph.D. dissertation, 1978.

Houck, James P. and Abraham Subotnik. The U.S. Supply of Soybeans: Regional Acreage Functions. Agricultural Economics Research, 21:4, October 1969.

_____, M.E. Ryan, and S. Subotnik. Soybeans and their Products Markets, Models, and Policy. Minneapolis, University of Minnesota Press, 1972.

_____, et al. Analyzing the Impact of Government Programs in Crop Acerage. Technical Bulletin No. 1548. Washington, D.C., U.S. Department of Agriculture, Economic Research Service, August 1976.

Hulten, Charles R. Divisia Index Numbers. Econometrica, 41:1017-25, 1973.

International Monetary Fund. International Financial Statistics Yearbook. Washington, D.C., 1980.

Jorgenson, Dale W. and Zvi Griliches. The Explanation of Productivity Change. Review of Economic Studies 34:249-283, 1967.

_____, Lawrence Lau and Timothy Stoker. Welfare Comparison Under Exact Aggregation. Paper presented at American Economic Association Meetings, December 1979.

_____, J.J. McCall and R. Radner. Optimal Replacement Policy. Amsterdam/New York, North Holland, 1967.

Just, Richard E. and Darrell L. Hurth. Welfare Measures in a Multi-Market Framework. American Economic Review 69:947-954, 1979.

Karn, J.F. and J.M. Quigley. Measuring the Value of Housing Quality. Journal of the American Statistical Association 65:532-548, May 1970.

Kendrick, John W. and Beatrice N. Vaccara. New Developments in Productivity Measurement and Analysis. NBER Studies in Income and Wealth, Vol. 44. Chicago, University of Chicago Press, 1980.

Klein, Lawrence and H. Rubin. A Constant-Utility Index of the Cost of Living. Review of Economic Studies 15:84-87, 1947.

Kmenta, Jan. Elements of Econometrics. New York, Macmillan, 1971.

_____. Some Properties of Alternative Estimates of a Cobb-Douglas Production Function. Econometrica 32:183-188, 1964.

_____ and Roy F. Gilbert. Small Sample Properties of Alternative Estimators of Seemingly Unrelated Regressions. Journal of the American Statistical Association 63:1180-1200, 1968.

Lancaster, Kelvin G. A New Approach to Consumer Theory. Journal of Political Economy 74:132-157, 1966.

Lau, Lawrence J. Existence Conditions for Aggregate Demand Functions: The Case of a Single Index. Technical Report No. 248, Institute for Mathematical Studies in the Social Sciences, Stanford University, October 1977.

_____, Wuu-Long Lin and Pan A. Yotopoulos. The Linear Logarithmic Expenditure System: An Application to Consumption - Leisure Choice. Econometrica 46:843-868, 1978.

Lind, Robert C. Spatial Equilibrium, the Theory of Rents, and the Measurement of Benefits from Public Programs. Quarterly Journal of Economics 87:188-207, 1973.

Lucas, Robert E.B. Hedonic Wage Equations and Psychic Wages in the Returns to Schooling. American Economic Review 67:549-558, 1977.

Maddala, G. Econometrics. New York, McGraw-Hill, 1977.

Mäler, Karl-Göran. Environmental Economics: A Theoretical Inquiry. Baltimore, Johns Hopkins University Press, 1974.

Meyer, J. and R. Leone. The Urban Disamenity Revisited. In: Lowdon Wingo and Alan Evans (eds.) Public Economics and the Quality of Life, Baltimore, Johns Hopkins University Press, 1977.

Michigan, University. Institute for Social Research. Panel Study on Income Dynamics, 1971.

Mieszkowski, Peter and Mahlon Straszheim (eds.) Current Issues in Urban Economics. Baltimore, Johns Hopkins University Press, 1979.

Mishan, E.J. Cost-Benefit Analysis (2nd Edition). New York, Praeger, 1976.

Moroney, J.R. The Structure of Production in American Manufacturing. Chapel Hill, University of North Carolina Press, 1972.

Muellbauer, J. Household Production Theory, Quality and the Hedonic Technique. American Economic Review 64:977-994, 1974.

Muth, Richard. Household Production and Consumer Demand Functions. Econometrica 34:699-708, 1966.

Nakamura, Masao, Alice Nakamura, and Dallas Cullen. Job Opportunities, the Offered Wage, and the Labor Supply of Married Women. American Economic Review 69:787-805, 1979.

Nerlove, Marc. Returns to Scale in Electricity Supply, in Carl F. Christ et al. Measurement in Economics: Studies in Mathematical Economics and Econometrics. Stanford, Stanford University Press, 1963, pp. 167-198.

Nordhaus, W. and J. Tobin. Is Growth Obsolete in Economic Growth? New York, National Bureau of Economic Research, 1972.

Ohta, Makoto and Zvi Griliches. Makes and Depreciation in the U.S. Passenger Car Market. Mimeographed, Harvard University, 1972.

Pindyck, Robert S. Interfuel Substitution and the Industrial Demand for Energy: An International Comparison. Review of Economics and Statistics 61:169-179, 1979.

_____ and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts. New York, McGraw-Hill, 1976.

Pitkin, John and George Masnick. Projections of Housing Consumption in the U.S., 1980 to 2000, By a Cohort Method. Annual Housing Survey Studies, No. 9. Washington, D.C. U.S. Department of Housing and Urban Development, Office of Policy Development and Research. June 1980.

Pogue, Gerald A. Estimation of the Cost of Capital for Major U.S. Industries with Application to Pollution-Control Investments. EPA-230/3-76-001, 1975.

Pollak, Robert A. Conditional Demand Functions and Consumption Theory. Quarterly Journal of Economics 83:60-78, 1969.

_____ and Michael Wachter. The Relevance of the Household Production Function and its Implications for the Allocation of Time. Journal of Political Economy 83(2):255-277, 1975.

_____ and Terence J. Wales. Comparison of the Quadratic Expenditure Expenditure System and Translog Demand Systems with Alternative Specifications of Demographic Effects. Econometrica 48:595-612, 1980.

_____. Estimation of Complete Demand Systems from Household Budget Data. American Economic Review 68:348-359, 1978.

Randall, Alan and John R. Stoll. Consumer's Surplus in Commodity Space. American Economic Review 70:449-455, 1980.

_____, Barry Ives, and E. Eastman. Bidding Games for Valuation of Aesthetic Environmental Improvements. Journal of Environmental Economics and Management 1:132-149, 1974.

Rosen, Harvey S. Taxes in a Labor Supply Model with Joint Wages-Hours Determination. Econometrica 44:485-507, 1976.

Rosen, Sherwin. Hedonic Prices and Implicit Markets: Product Differentiation in Perfect Competition. Journal of Political Economy 82:34-55, 1974.

_____. Wage-Based Indexes of Urban Quality of Life, in Peter Mieszkowski and Mahlon Straszheim (eds.) Current Issues in Urban Economics. Baltimore, Johns Hopkins University Press, 1979.

Samuelson, Paul. The Problem of Integrability in Utility Theory. Econometrica 17:335-385, 1950.

Schmalensee, Richard. Another Look at the Social Valuation of Input Price Changes. American Economic Review, 66:239-243, 1976.

Schnore, Ann B. and Raymond J. Struyk. Segmentation in Urban Housing Markets. Journal of Urban Economics 3:146-166, 1976.

Shephard, Ronald W. Theory of Cost and Production Functions. Princeton, Princeton University Press, 1953, 1970.

Star, Spencer and Robert E. Hall. An Approximate Divisia Index of Total Factor Productivity. Econometrica 44:257-263, 1976.

Stone, Richard. Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand. The Economic Journal 64:511-527, 1954.

Straszheim, Donald H. and Mahlon R. Strazheim. An Econometric Analysis of the Determination of Prices in Manufacturing Industries. Review of Economics and Statistics 58:191-201, 1976.

Strazheim, Mahlon. Hedonic Estimation of Housing Market Prices: A Further Comment. Review of Economics and Statistics 56:404-406, 1974.

Strotz, Robert H. The Empirical Implications of a Utility Tree. Econometrica 25:269-280, 1957.

_____. The Use of Land Value Changes to Measure the Welfare Benefits of Land Improvements, in Joseph E. Haring, (ed.) The New Economics of Regulated Industries. Los Angeles, Occidental College, 1968, pp. 174-186.

Taylor, Lester. The Demand for Energy: A Survey of Price and Income Elasticities. In: W.D. Nordhaus (ed.) International Studies of the cemand for Energy. Amsterdam, North Holland, 1977, pp. 3-43.

Telser, Lester G. Iterative Estimation of a Set of Linear Regression Equations. Journal of the American Statistical Association 59:845-862, 1964.

Thaler, R. and Sherwin Rosen. The Value of Saving a Life: Evidence from the Labor Market, in N.E. Terleckyj (ed.) Household Production and Consumption. New York, National Bureau of Economic Research, 1975, pp. 265-298.

Theil, Henri. Economics and Information Theory. Chicago, Rand McNally, 1967.

United Nations, Food and Agriculture Organization. Monthly Bulletin of Agricultural Economics and Statistics. Rome, Italy, various issues from 1955 to 1977.

U.S. Bureau of Economic Analysis. Business Statistics 1977 Biennial Edition. Washington, D.C.

_____. Interindustry Transactions in New Structures and Equipment, 1963 and 1967, Vol. 1, 1975.

_____. Press Release (BEA 80-74), December 9. 1980.

_____. Survey of Current Business. Various Issues.

U.S. Bureau of Labor Statistics. Average Retail Prices of Selected Commodities and Services, Fall 1971, Washington, D.C., U.S. Government Printing Office, 1973.

_____. Capital Stock Estimates for Input-Output Industries: Methods and Data. Bulletin 2034. Washington, D.C., U.S. Government Printing Office, 1979.

_____. Consumer Expenditure Survey: Integrated Diary and Interview Survey Data, 1972-73. Bulletin 1992, Washington, D.C., U.S. Government Printing Office, 1978.

_____. Estimated Retail Prices and Indexes of Fuels and Utilities, 1973.

_____. Estimated Retail Food Prices by Cities, annual averages 1972-1975.

_____. Handbook of Labor Statistics, 1978, Bulletin 2000; and 1979, Bulletin 2070. Washington, D.C., U.S. Government Printing Office, 1979, 1980.

_____. Handbook of Methods, Bulletin 1910. Washington, D.C., U.S. Government Printing Office, 1976.

_____. Office of Prices and Living Conditions. Wholesale Prices and Price Indexes. Data for month of October, 1975-1977. Washington, D.C. U.S. Government Printing Office.

_____. Three Standards of Living for an Urban Family of Four Persons. Washington, D.C., Spring 1967.

U.S. Bureau of the Census. Annual Housing Survey, 1974-1976: Housing Characteristics for Selected Metropolitan Areas. Washington, D.C., GPO, 1976-1978.

_____. Annual Survey of Manufactures, 1955-1971.

_____. Census of Housing, 1970: Metropolitan Housing Characteristics. Washington, D.C., GPO, 1972.

_____. Census of Manufactures, 1954. Vols. 1,3: Summary and Area Statistics.

_____. Census of Manufactures, 1958. Vols. 1,3: Summary and Area Statistics.

_____. Census of Manufactures, 1963. Vols. 1,3: Summary and Area Statistics.

_____. Census of Manufactures, 1967. Vols. 1,3: Summary and Area Statistics.

_____. Census of Manufactures, 1972. Vols. 1,3: Summary and Area Statistics.

_____. Census of Population, 1970. (1 in a 100 Public Use Tape). Washington, D.C., U.S. Government Printing Office.

_____. County and City Data Book. 1972, 1977, Washington, D.C., GPO, 1973 and 1978.

_____. Pollution Abatement Costs and Expenditures. Annual 1973-1978. Current Population Reports Series MA-200.

_____. Projections of the Number of Households and Families: 1979 to 1995. Current Population Reports. Series P-25, No. 805, 1979.

_____. Projections of the Population of the United States: 1977 to 2050. Current Population Reports. Series P-25, No. 704. July 1977.

_____. Selected Industrial Air Pollution Control Equipment, 1971-1979. Current Industrial Reports, Series MA-35J. Washington, D.C. U.S. Government Printing Office.

_____. Statistical Abstract of the United States. Various years. Washington, D.C., U.S. Government Printing Office.

U.S. Congress. House. Committee on Interstate and Foreign Commerce. Subcommittee on Oversight and Investigations. Hearings on Acid Rain held February 26/27, 1980. 96th Congress, 2nd Session. Washington, D.C., GPO, 1980.

U.S. Department of Agriculture. Agricultural Statistics Annual. 1954-1979.

_____. County Statistics. Various States 1975-1977.

_____. Crop Reporting Board. Agricultural Prices, Annual Summary 1975-1977.

_____. Crop Reporting Board. Crop Production. Annual. 1974-1979.

_____. Crop Reporting Board Catalog 1980 Releases. Washington, D.C., January 1980.

_____. Field Crops: Area, Yield and Production by States, 1969-1974. Statistical Bulletin 582. Washington, D.C., December 1977.

_____. Meat Animals: Production Disposition, Income 1978-1979. Washington, D.C., April 1980.

_____. Economic Research Service. Changes in Farm Production and Efficiency. Statistical Bulletin No. 581, 1977.

_____. Economic Research Service. Fats and Oils Situation. No. FOS-276 to No. FOS-289.

_____. Economic Research Service. Fertilizer Situation. Annual. 1975-1978.

_____. State Extension Services. Reports of Tonnage of Agricultural Limestone Used in the United States. 1975-1977.

U.S. Department of Commerce. Statistical Abstract of the United States, 1978.

U.S. Department of Commerce News. Projections of Personal Income to the Year 2000. December 9, 1980.

U.S. Department of Energy, Energy Information Administration. Annual Report to Congress - 1980 (Volume 3: Forecasts). Washington, D.C.: U.S. Government Printing Office, 1981.

U.S. Federal Power Commission. Annual Survey of Cost and Quality of Electric Utility Plant Fuels, 1973-1977.

_____. Hydroelectric Plant Construction Cost and Annual Production Expenses 1953-1956. Supplement No. 16, 1972. Washington, D.C., 1975.

_____. Statistics of Privately Owned Electric Utilities in the U.S., 1972 and 1975. Washington, D.C.

_____. Steam-Electric Plant Air and Water Quality Control Data. Annual, 1969-1976.

U.S. Internal Revenue Service. Report of the Commissioner of Internal Revenue, 1972-1973.

U.S. Office of the Federal Register. Code of Federal Regulations, Title 21 (Food and Drugs) Part 110, April 1, 1980.

Varian, Hal. Microeconomic Analysis. New York, Norton, 1978.

Viscusi, W. Kip. Wealth Effects and Earnings Premiums for Job Hazards. Review of Economics and Statistics 60:408-416, 1978.

Von Furstenberg, George M., ed. Capital Efficiency and Growth. Cambridge, MA, Ballinger, 1980.

Wales, Terence. Labor Supply and Commuting Time: An Empirical Study Journal of Econometrics 8:215-226, 1978.

_____ and A.D. Woodland. Estimation of Household Utility Functions and Labor Supply Response. International Economic Review 17:397-410, 1976.

_____. Estimation of the Allocation of Time for Work, Leisure, and Housework. Econometrica 45:115-132, 1977.

Walters, A.A. Econometric Studies of Production, in A.A. Walters. An Introduction to Econometrics. New York, Norton, 1971, pp. 269-340.

_____. Production and Cost Functions: An Econometric Survey. Econometrica 31:1-66, 1963.

Wharton EFA Inc. The Wharton EFA Annual Model: Historical Tables, 1955-1976.

Willig, Robert D. Consumers' Surplus Without Apology. American Economic Review 66:589-597, 1976.

Wingo, Lowdon and Alan Evans, eds. Public Economics and the Quality of Life. Baltimore, Johns Hopkins University Press, 1977.

Witte, Ann D. and Sharon K. Long. Evaluating the Effects of Public Policies on Land Prices in Metropolitan Areas: Some Suggested Approaches. Paper presented at HUD Seminar on Land Prices and Public Policy, Washington, D.C., February 4-5, 1980.

Womack, Abner. The U.S. Demand for Corn, Sorghum, Oats, and Barley: An Econometric Analysis Economic Report 76-5. St. Paul, University of Minnesota, August 1976.

Zellner, Arnold. An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias. Journal of the American Statistical Association 57:348-368, 1962.

_____, Jan Kmenta and J. Dreze. Specification and Estimation of Cobb-Douglas Production Function Models. Econometrica 34:784-795, 1966.

BIBLIOGRAPHY — PART B

SOURCES OF INFORMATION ON POLLUTION

Adams, R.M., et al. Methods Development for Assessing Air Pollution Control Benefits, Vol. 3: A Preliminary Assessment of Air Pollution Damages for Selected Crops Within Southern California. Prepared for the U.S. Environmental Protection Agency. Laramie, University of Wyoming, February 1979.

Anderson, Robert J., Jr. and Thomas D. Crocker. Air Pollution and Residential Property Values. Urban Studies 8:171-180, 1971.

_____. Air Pollution and Property Values: A Reply. Review of Economics and Statistics 54:470-473, 1972.

Appel, David. Estimating the Benefits of Air Quality Improvement: An Hedonic Price Index Approach Applied to the New York Metropolitan Area, unpublished Ph.D. dissertation, Rutgers University, 1980.

Armentano, T.V., et al. Calculation of Yield-Loss Coefficients for Major Crops in the Ohio River Basin, in Orie L. Loucks (ed.), Crop and Forest Losses Due to Current and Projected Emissions from Coal-Fired Power Plants in the Ohio River Basin. Final Draft Report. Indianapolis, Indiana, The Institute of Ecology. June 1980, pp. 88-145.

Barnes, R.A. The Long Range Transport of Air Pollution: A Review of European Experience. Journal of the Air Pollution Control Association 29:1219-1235, 1979.

Barrett, Larry B. and Thomas E. Waddell. Cost of Air Pollution Damage: A Status Report. Research Triangle Park, NC, National Environmental Research Center, February 1973.

Basala, Allen and Hugh Devine. Feasibility Analysis for Benefit Assessment of SO_x and PM Air Pollution Control: A Theoretical Procedure, prepared for U.S. Environmental Protection Agency, Economic Analysis Branch, January 25, 1980.

Battelle Columbus Laboratories. Economic Effects of Metallic Corrosion in the U.S. - Appendix B Part 2. Prepared for National Bureau of Standards (NBS No. 511-2). Washington, D.C., May 1978.

Bawa, Vijay S. On Optimal Pollution Control Policies, Economic Discussion Paper No. 27. Holmdel, NJ, Bell Telephone Laboratories, May 1975.

Benedict, H.M., C.J. Miller and R.E. Olson. Economic Impact of Air Pollutants on Plants in the United States. Menlo Park, CA, Stanford Research Institute, November 1971.

_____ and J.S. Smith. Assessment of Economic Impact of Air Pollutants on Vegetation in the United States - 1969 and 1971. Menlo Park, CA, Stanford Research Institute, 1973.

Bhargava, R.P. Selection of a Subset of Pollution Stations in the Bay Area of California on the Basis of the Characteristic, 24-Hour Suspended Particulate Concentration, from the Viewpoint of Variation. Statistics and Environmental Factors in Health: Technical Report No. 37. New Canaan, CT, SIAM Institute for Mathematics and Society, April 1980.

Bich, Tran Thi Ngoc and V. Kerry Smith. The Role of Air and Water Residuals for Steam Electric Power Generation. Unpublished.

Bishop, John and Charles Cicchetti. Some Institutional and Conceptual Thoughts on the Measurement of Indirect and Intangible Benefits and Costs, in Henry M. Peskin and Eugene P. Seskin (eds.) Cost Benefit Analysis and Water Pollution Policy. Washington, D.C., The Urban Institute, 1975.

Bohne, H. Schadlichkeit von Staub aus Zementwerken fur Haldbestande. Allg. Forstz 18:107-111, 1963.

Booz Allen and Hamilton, Inc. Study to Determine Residential Soiling Costs of Particulate Air Pollution. Raleigh, NC, National Air Pollution Control Administration, October 1970.

Bornstein, Robert D. Annotated Bibliography of Recent Publications on California Air Pollution. 4 Vols. Statistics and Environmental Factors in Health: Technical Reports No. 39-42. New Canaan, CT, SIAM Institute for Mathematics and Society, July 1980.

Brisley, H.R. and W.W. Jones. Sulfur Dioxide Fumigation of Wheat with Special Reference to its Effect on Yield. Plant Physiology 25:666-681, 1950.

_____, C.R. Davis, and J.A. Booth. Sulfur Dioxide Fumigation of Cotton With Special Reference to Its Own Effect on Yield. Agronomy Journal 51:77-80, 1959.

Brookshire, David S. et al. Methods Development for Assessing Tradeoffs in Environmental Management. Vol. 2: Experiments in Valuing Non-Market Goods: A Case Study of Alternative Benefit Measures of Air Pollution Control in the South Coast Air Basin of Southern California. Prepared for the U.S. Environmental Protection Agency. Laramie, University of Wyoming, September 1, 1978.

_____. Methods Development for Assessing Tradeoffs in Environmental Management. Vol. 5: Executive Summary. Prepared for the U.S. Environmental Protection Agency. Laramie, University of Wyoming, November 13, 1978.

Business Roundtable Air Quality Project:

Harvard University. School of Public Health and Division of Applied Sciences. National Ambient Air Quality Standards. Vol. 1. Cambridge, MA, November 1980.

Arthur D. Little, Inc. The Effects of Prevention of Significant Deterioration on Industrial Development. Vol. III. Cambridge, MA, November 1980.

Environmental Research and Technology, Inc. The Impact of Air Quality Permits Procedures on Industrial Planning and Development. Vol. III. Concord, MA, November 1980.

National Economic Research Associates, Inc. Cost Effectiveness and Cost-Benefit Analysis of Air Quality Regulation. Vol. IV. Washington, D.C., November 1980.

California. State. Air Resources Board. Ten-Year Summary of California Air Quality Data 1963-1972. Sacramento, CA, January 1974.

Clean Air Act of 1970 42 USC 7401 et seq. (PL91-604) December 31, 1970. Clean Air Act Amendments of 1977 (PL95-95) August 7, 1977.

Cowling, D.W., L.H.P. Jones and D.R. Lockyer. Increased Yield Through Correction of Fulfur Deficiency in Ryegrass Exposed to Sulfur Dioxide. Nature 243:479-480, 1973.

Crocker, Thomas D. Urban Air Pollution Damage Functions: Theory and Measurement, prepared for U.S. Environmental Protection Agency, Office of Air Programs. Riverside, University of California, June 15, 1971.

_____ and Bruce A. Foster. Decision Problems in the Control of Acid Precipitation: Nonconvexities and Irreversibilities, unpublished paper, 1980.

_____. A First Exercise in Assessing the Economic Benefits of Controlling Acid Precipitation, prepared for U.S. Environmental Protection Agency, Office of Health and Ecological Effects, January 1980.

_____, et al. Methods Development for Assessing Tradeoffs in Environmental Management, Vol. 1: Experiments in the Economics of Air Pollution Epidemiology. Prepared for the U.S. Environmental Protection Agency, Laramie, University of Wyoming, November 13, 1978.

Cropper, Maureen L., et al. Methods Development for Assessing Air Pollution Control Benefits. Vol. 4: Studies on Partial Equilibrium Approaches to Valuation of Environmental Amenities. Prepared for the U.S. Environmental Protection Agency. Riverside, University of California, September 1, 1978.

Deyak, Timothy A., and V. Kerry Smith. Residential Property Values and Air Pollution: Some New Evidence. Quarterly Review of Economics and Business 14:93-100, 1974.

Dunbar, Frederick C. Secondary Standards for SO_x and Particulates: Economic Effects, paper presented before the American Air Pollution Control Association Specialty Conference on Secondary Standards for SO_x Particulates, Atlanta, GA, September 17, 1980.

Dvorak, A.J. et al. Impacts of Coal-Fired Power Plants on Fish, Wildlife, and their Habitats, prepared by Argonne National Laboratory, Division of Environmental Impact Studies for the U.S. Fish and Wildlife Service, Office of Biological Services and Environmental Contaminants Evaluation, Power Plant Project/Coal Project (FWS/OBS-78/29). Washington, D.C., GPO, March 1978.

Economics of Air Pollution. ORBIT Search Bibliography, November 30, 1977.

Energy and Environmental Analysis, Inc. Feasibility of a Welfare Benefits Analysis for TSP and SO_x, prepared for U.S. Environmental Protection Agency, Economic Analysis Branch, January 15, 1980.

EPA Briefing on Particulate/SO_x Regulatory Analysis, January 18, 1980 and Memorandum on meeting January 22, 1980.

EPA Memorandum on NO_x Regulatory Analysis Meeting, January 24, 1980.

Eureka Laboratories, Inc. The Economic Effect of Air Pollution of Agricultural Crops: Application and Evaluation of Methodologies, A Case Study. Interim report prepared for U.S. Environmental Protection Agency, Environmental Research Laboratory. Sacramento, CA, November 1979.

Faith, Ray and Ruth Sheshinski. Misspecification of Trend in Spatial Random Function Interpolation with Application to Oxidant Mapping. Statistics and Environmental Factors in Health: Technical Report No. 28. Philadelphia, SIAM Institute for Mathematics and Society, September 1979.

Faller, N. Effects of Atmospheric SO_2 on Plants. Sulfur Institute Journal 6:5-7, 1970.

Feenberg, Dan. Measuring the Benefits of Water Pollution Control, forthcoming.

Feliciano, A. 1971 Survey and Assessment of Air Pollution Damage to Vegetation in New Jersey. New Brunswick, NJ, Rutgers University, Cooperative Extension Service, 1972.

Fink, F.W., F.H. Buttner and W.K. Boyd. Technical-Economic Evaluation of Air-Pollution Corrosion Costs on Metals in the U.S. (NTIS-PB198-453). Columbus, OH, Battelle Memorial Institute, February 19. 1971.

Fleiss, Joseph L. Inference about Population Attributable Risk from Cross-Sectional Studies. Statistics and Environmental Factors in Health: Technical Report. Philadelphia, SIAM Institute for Mathematics and Society, March 26, 1979.

Freeman, A. Myrick III. Air Pollution and Property Values: A Methodological Comment. Review of Economics and Statistics 53:415-416, 1971.

_____. Air Pollution and Property Values: A Further Comment. Review of Economics and Statistics 56:554-556, 1974.

_____. The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, prepared for Council on Environmental Quality, July 1979.

_____. The Benefits of Environmental Improvement: Theory and Practice. Baltimore, Johns Hopkins University Press, 1979.

_____. Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues. Scandinavian Journal of Economics 154-173, 1979.

_____. On Estimating Air Pollution Control Benefits from Land Value Studies. Journal of Environmental Economics and Management 1:74-83, 1974.

Gianessi, Leonard P., Henry Peskin and Edward Wolff. The Distributional Implications of National Air Pollution Damage Estimates, prepared for the Conference on Research and Income and Wealth, University of Michigan, May 15-17, 1974. New York, National Bureau of Economic Research, June 4, 1974.

Gillette, Donald G. Sulfur Dioxide and Material Damage. Journal of the Air Pollution Control Association 25:1238-1243, 1975.

Graves, Philip, Ronald Krumm and Daniel Violette. Estimating the Benefits of Improved Air Quality, prepared for the Benefit Methodology Panel, National Commission on Air Quality, December 1979.

Grivet, Cyril D. Modeling and Analysis of Air Quality Data. Statistics and Environmental Factors in Health: Technical Report No. 43. New Canaan, CT, SIAM Institute for Mathematics and Society, September 1980.

Guderian, R. Air Pollution: Phytotoxicity of Acidic Gases and Its Significance in Air Pollution Control. Berlin, Springer-Verlag, 1977.

Hallgren, J.E. Physiological and Biochemical Effects of Sulfur Dioxide on Plants, in J.O. Nriagu (ed.) Sulfur in the Environment Vol. 2. New York, John Wiley & Sons, 1978. pp. 163-210.

Harrison, David and Daniel L. Rubinfeld. Hedonic Housing Prices and the Demand for Clean Air. Journal of Environmental Economics and Management 5:81-102, 1978.

_____. The Air Pollution and Property Value Debate. Review of Economics and Statistics 60:635-638, 1978.

Haynie, Fred H. Economic Assessment of Pollution Related Corrosion Damage. Paper presented at the Electrochemical Society Symposium on Atmospheric Corrosion, October 6, 1980.

Heagle, A.S. Ranking of Soybean Cultivars for Resistance to Ozone Using Different Ozone Doses and Response Measures. Environmental Pollution 19:1-10, 1979.

Heck, W.W. Factors Influencing Expression of Oxidant Damage to Plants. Annual Review of Phytopathology 6:165-188, 1968.

_____. Plant and Microorganisms, in Environmental Health Effects, Vol. 2. Ozone and Other Photochemical Oxidants. EPA-600/1-76-0276. Research Triangle Park, NC, U.S. Environmental Protection Agency, Office of R&D, 1976.

Horne, Julie. Visibility Regulations, paper presented at the Air Pollution Control Association Specialty Conference on Visibility, Denver, November 27-28, 1979 in Journal of the Air Pollution Control Association 30:120-122, 1980.

Institute for Defense Analyses. Economic and Social Measures of Biologic and Climatic Change, CIAP Monograph 6, prepared for the Department of Transporation, Climate Impact Assessment Program (NTIS DOT-TST-75-56). Arlington, VA, September 1975.

JRB Associates. Technological Feasibility Assessment and Inflationary Impact Statement of the Proposed Standard for Sulfur Dioxide, 29CFR1910.1030. Washington, D.C., U.S. Occupational Health and Safety Administration, January 31, 1977.

Jacobson, J.S. and A.C. Hill. Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Pittsburgh, PA. Air Pollution Control Association, 1970.

Kelly, Gabrielle. Pollutant Standards Index PSI. Statistics and Environmental Factors in Health: Working Paper No. 11. Philadelphia, SIAM Institute for Mathematics and Society, September 1979.

Kress, Lance W. and John M. Skelly. Prevention of Significant Deterioration of Native Ecosystems -- Allowable Pollutant Concentrations, Corvallis, OR, Corvallis Environmental Research Laboratory, September 6, 1979.

Krupa, S.V., et al. Impact of Air Pollutants on Terrestrial Vegetation - A Literature Survey. State of Minnesota Environmental Quality Council, 1976.

Lacasse, N.L. Assessment of Air Pollution Damage to Vegetation in Pennsylvania. State College, PA, Center for Air Environment Studies, 1971.

_____, T.C. Weidensaul, and J.W. Carroll. Statewide Survey of Air Pollution Damage to Vegetation, 1969. State College, PA, Center for Air Environment Studies, January 1970.

Larsen, Ralph I. An Air Quality Data Analysis System for Interrelating Effects, Standards and Needed Source Reductions. Journal of the Air Pollution Control Association 23:933-940, 1973.

_____. An Air Quality Data Analysis System for Interrelating Effects, Standards and Needed Source Reductions, Part II. Journal of the Air Pollution Control Association 24:551-558, 1974.

_____. An Air Quality Data Analysis System for Interrelating Effects, Standards and Needed Source Reductions, Part IV. Journal of the Air Pollution Control Association 27:454-459, 1977.

_____. A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards. Research Triangle Park, NC, U.S. Environmental Protection Agency, Office of Air Programs, November 1971.

_____. A New Mathematical Model of Air Pollutant Concentration Averaging Time and Frequency, Journal of the Air Pollution Control Association 19:24-30, 1969; Comment 23:291-292, 1973; Reply 23:292, 1973.

_____. Relating Air Pollution Effects to Concentrations and Control, Journal of the Air Pollution Control Association 20:214-225, 1970.

_____ and Walter W. Heck. An Air Quality Data Analysis System for Interrelating Effects, Standards and Needed Source Reductions, Part III. Journal of the Air Pollution Control Association 26:325-333, 1976.

Latimer, Douglas. Power Plant Impacts on Visibility in the West: Siting and Emissions Control Implications, paper presented at the Air Pollution Control Association Specialty Conference on Visibility, Denver, November 27-28, 1979 in Journal of the Air Pollution Control Association 30:142-146, 1980.

Lave, Lester. Air Pollution Damage: Some Difficulties in Estimating the Value of Abatement, in Allen V. Kneese and Blair T. Bower (eds.) Environmental Quality Analysis. Baltimore, Johns Hopkins University Press for Resources for the Future, 1972, pp. 213-242.

_____ and Eugene Seskin. Air Pollution and Human Health. Baltimore, Resources for the Future, 1977.

Leung, S. et al. The Economic Effect of Air Pollution on Agricultural Crops: Application and Evaluation of Methodologies, A Case Study. Interim Report prepared for Corvallis Environmental Research Laboratory. Sacramento, CA, Eureka Laboratories, Inc., November 1979.

_____. Methodologies for Valuation of Agricultural Crop Yield Changes: A Review. (EPA-600/5-78-018). Corvallis, OR, U.S. Environmental Protection Agency, Office of Research and Development, August 1978.

Lewis, William H., Jr. Protection Against Visibility Impairment Under the Clean Air Act, paper presented at the Air Pollution Control Association Specialty Conference on Visibility, Denver, November 27-28, 1979 in Journal of the Air Pollution Control Association 30:118-120, 1980.

Linzon, S.N. Effects of Airborne Sulfur Pollutants on Plants, in J.O. Nriagu (ed.) Sulfur in the Environment Vol. 2. New York, John Wiley & Sons, 1978, pp. 109-162.

Lipfert, Frederick W. On the Evaluation of Air Pollution Control Benefits, prepared for the National Commission on Air Quality, November 1979.

Liu, Ben-chieh and Eden Siu-hung Yu. Physical and Economic Damage Functions for Air Pollutants by Receptors (EPA-600/5-76-011), prepared for Corvallis Environmental Research Laboratory, September 1976.

_____, Mary Kies and Jim Miller. Damage Functions for Air Pollutants, prepared for Washington Environmental Research Center. Kansas City, MO, Midwest Research Institute, February 10, 1976.

Lokey, Don, Harvey Richmond and Michael Jones. Revision of the Ozone Secondary National Ambient Air Quality Standard. Research Triangle Park, NC, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Strategies and Air Standards Division, 1979.

Malm, William C., Karen K. Leiker and John V. Molenar. Human Perception of Visual Air Quality, paper presented at the Air Pollution Control Association Specialty Conference on Visibility, Denver, November 27-28, 1979 in Journal of the Air Pollution Control Association 30:122-131, 1980.

Mathtech, Inc. Notes on a Study of Benefits of Alternative Secondary Standard Levels for TSP and SO_2. U.S. Environmental Protection Agency, Economic Analysis Branch, September 28, 1979.

McFadden, James E. and Michael D. Koontz. Sulfur Dioxide and Sulfates Materials Damage Study, prepared for U.S. Environmental Protection Agency, Environmental Sciences Research Laboratory. Gaithersburg, MD, Geomet Inc., February 1980.

Middleton, J.T. and A.O. Paulus. The Identification and Distribution of Air Pollutants Through Plant Response. Arch. Indust. Health 14:526-532, 1956.

Millecan, A.A. A Survey and Assessment of Air Pollution Damage to California Vegetation. California Department of Agriculture, June 1971.

_____. A Survey and Assessment of Air Pollution Damage to California Vegetation. Sacramento, CA, Department of Food and Agriculture, 1976.

Miller, J.E. and D.G. Sprugel. Some Preliminary Notes Concerning the Impact of Fossil Fuel Combustion on Crop Plants. Argonne, IL, Argonne National Laboratory, 1979.

Miller, V.L., R.K. Howell, and B.E. Caldwell. Relative Sensitivity of Soybean Genotypes to Ozone and Sulfur Dioxide. Journal of Environmental Quality 3:35-37, 1974.

Moskowitz, Paul D., et al. Economic Assessment — Impacts of Oxidants and Sulfur Dioxide Air Pollution on Agricultural Productivity. Paper presented at National Crop Loss Assessment Network Annual Program Review, December 15-19, 1980. Upton, N.Y., Brookhaven National Laboratory, 1980.

_____. Oxidant Air Pollution: Estimated Effects on U.S. Vegetation in 1969 and 1974. Paper prepared for U.S. Environmental Protection Agency, Environmental Research Laboratory. Upton, N.Y., Brookhaven National Laboratory, November 1980.

Mudd, J.B. and T.T. Kozlowski, eds. Physiological Ecology. A Series of Monographs, Texts, and Treatises. Responses of Plants to Air Pollution. New York, Academic Press, 1975.

Naegele, J.A., ed. Air Pollution Damage to Vegetation. Advanced Chemistry Series 122. Washington, D.C., American Chemistry Society, 1973.

_____, W.A. Feder, and C.J. Brandt. Assessment of Air Pollution Damage to Vegetation in New England, July 1971 - July 1972. Waltham, MA, University of Massachusetts. Suburban Experiment Station, 1972.

National Academy of Science. Coordinating Committee on Air Quality Studies. The Costs and Benefits of Automobile Emissions Control: Vol. 4 of Air Quality and Automobile Emissions Control, Washington, D.C., 1974.

National Research Council. Board on Toxicology and Environmental Health Hazards. Committee on SO_x. Sulfur Oxides. Washington, D.C., National Academy of Sciences, 1978.

National Research Council. Commission on Natural Resources. Air Quality and Stationary Source Emission Control. Prepared for the Committee on Public Works, U.S. Senate, pursuant to S.Res 135. Washington, D.C., 1975.

Nelson, Jon P. Economic Analysis of Transportation Noise Abatement. Cambridge, MA, 1978.

_____. The Effects of Mobile Source Air and Noise Pollution on Residential Property Values. Washington, D.C., U.S. Department of Transportation, 1975.

_____. Residential Choice, Hedonic Prices, and the Demand for Urban Air Quality. Journal of Urban Economics 5:357-369, 1978.

Niskanen, William A. and Steve H. Hanke. Land Prices Substantially Underestimate the Value of Environmental Quality. Review of Economics and Statistics 59:375-377, 1977.

Noggle, J.C. and H.C. Jones. Accumulation of Atmospheric Sulfur by Plants and Sulfur-Supplying Capacity of Soils. EPA-600-7-79-109. Research Triangle Park, NC, U.S. Environmental Protection Agency, 1979.

Nriagu, J.O., ed. Sulfur in the Environment. Part 1: The Atmospheric Cycle; Part 2: Ecological Impacts. New York, John Wiley & Sons, 1978.

Ohio River Basin Energy Study (ORBES):

Loucks, Orie L., ed. Crop and Forest Losses Due to Current and Projected Emissions from Coal-Fired Power Plants in the Ohio River Basin. Final Draft Report. Indianapolis, IN, The Institute of Ecology, June 1980.

Miller, Richard and Roland Usher. Modification of Crop Effects Estimates Based on Peak-Load Emissions. (Comment on Loucks above), 1980.

Page, Walter P. and John M. Gowdy. Economic Losses in the Columbus SMSA Due to Long-Range Transport of Airborne Residuals in the ORBES Region. Draft, prepared for ORBES, June 1980.

Randolph, J.C. and W.W. Jones. Ohio River Basin Energy Study: Land Use and Terrestrial Ecology. Draft Final Report, prepared for U.S. EPA, Office of R&D, June 18, 1980.

Teknekron Research, Inc. Air Quality and Meteorology in the Ohio River Basin - Baseline and Future Impacts. Prepared for U.S. EPA, Office of R&D. Waltham, MA, July 1980.

_____. Selected Impacts of Electric Utilities Operations in the Ohio River Basin (1976-2000): An Application of the Utility Simulation Model. Prepared for U.S. EPA, Office of R&D. Berkeley, CA, April 1980.

Organization for Economic Cooperation and Development. Environment Directorate, Air Management Group. The Costs and Benefits of Sulphur Oxide Control: A Methodological Study. Parts I and II. (ENV/AIR/80.03). Paris, May 5, 1980.

Oshima, R.J. Development of a System for Evaluating and Reporting Economic Crop Losses in California, III: Ozone Dosage-Crop Loss Conversion Function - Alfalfa, Sweet Corn. Final Report to California Air Resources Board, 1975.

_____, et al. Ozone Dosage-Crop Loss Function for Alfalfa: A Standardized Method for Assessing Crop Losses for Air Pollutants. Journal of the Air Pollution Control Association 26:861-865, 1976.

Ott, Wayne R. Models of Human Exposure to Air Pollution. Statistics and Environmental Factors in Health: Technical Report No. 32. New Canaan, CT. SIAM Institute for Mathematics and Society, July 1980.

Palmquist, Raymond B. Impact of Highway Improvements on Property Values in Washington. Olympia, WA, U.S. Department of Transporation, Washington State Transportation Commission, July 1979.

Paterson, Ernest W. Review of 'Oxidant Air Pollution: Estimated Effects on U.S. Vegetation in 1969 and 1974', by Paul D. Moskowitz, et al. December 1980.

Peckham, Brian. Air Pollution and Residential Property Values in Philadelphia. (Mimeo) 1970.

Pell, E.J. 1972 Survey and Assessment of Air Pollution Damage to Vegetation in New Jersey. New Brunswick, NJ, Rutgers University, Cooperative Extension Service, 1973.

Perl, Lewis J. Alternative Estimates of the Benefits of Sulfur Dioxide Emissions Control, prepared for the Benefit Estimation Methodology Panel, National Commission on Air Quality, November 27, 1979.

_____. Cost-Benefit Analysis of Environmental Regulation. Paper presented at the Conference on Cost-Benefit Analysis of Environmental Regulation. Chicago, IL, October 16, 1980.

Polinsky, A. Mitchell and Daniel L. Rubinfeld. The Air Pollution and Property Value Debate, Review of Economics and Statistics, 57:106-110, 1975.

_____. Property Values and the Benefits of Environmental Improvements: Theory and Measurement, in Lowdon Wingo and Alan Evans (eds.) Public Economics and the Quality of Life. Baltimore, Johns Hopkins University Press for Resources for the Future and the Centre for Environmental Studies, 1977.

_____ and Steven Shavell. The Air Pollution and Property Value Debate. Review of Economics and Statistics 57:100-104, 1975.

_____. Amenities and Property Values in a Model of An Urban Area. Journal of Public Economics 5:119-129, 1976.

Reinert, R.A., A.S. Heagle, and W.W. Heck. Plant Response to Pollutant Combinations, in J.B. Mudd and T.T. Koslowski (eds.) Responses of Plants to Air Pollution. New York, Academic Press, 1975, pp. 159-177.

Ricci, Paolo and Ronald Wyzga. The Health Effects of Reduced Air Pollution, prepared for the National Commission on Air Quality, November 7, 1979.

Ridker, Ronald G. Economic Costs of Air Pollution. New York, Praeger, 1967.

_____ and John A. Henning. The Determinants of Residential Property Values with Special Reference to Air Pollution. Review of Economics and Statistics 49:246-257, 1967.

_____, ed. Population, Resources and the Environment, Vol. III. Washington, D.C. U.S. Commission on Population Growth and the American Future, 1972.

Rowe, Robert D. and Lauraine G. Chestnut. Visibility Benefits Assessment Guidebook. Interim Report prepared for U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Denver, Abt/West, March 1981.

Ryan, John W., et al. An Estimate of the Nonhealth Benefits of Meeting the Secondary National Ambient Air Quality Standards. Final Report prepared for National Commission on Air Quality. Menlo Park, CA. SRI International, January 1981.

Salmon, R.L. Systems Analysis of the Effects of Air Pollution on Materials. Kansas City, MO, Midwest Research Institute, 1970.

Seneca, Joseph and Peter Asch. The Benefits of Air Pollution Control in New Jersey. New Brunswick, N.J., Center for Coastal and Environmental Studies, Rutgers University, April 1979.

Setterstrom, C. and P.W. Zimmerman. Factors Influencing Susceptibility of Plants to Sulfur Dioxide Injury. Contrib. Boyce Thompson Inst. 10:155-186, 1939.

Schwarz, H. Uber die Wirkung des Magetits beim Atmospherischen Rosten und beim Unterrosten von Austrichen. Werkst, Korros, 23:648-663, 1972.

Shy, Carl M., On Using Epidemiologic Evidence of Air Pollution Effects, prepared for the Benefit Methodology Panel, National Commission on Air Quality, December 10, 1979.

SIAM Institute for Mathematics and Society, Statistics and Environmental Factors in Health, Final Summary Report on SIMS Three-Year Study. Philadelphia, September 1979.

Small, Kenneth A. Air Pollution and Property Values: Further Comment. Review of Economics and Statistics 57:111-113, 1975.

Smith, V. Kerry. The Economic Consequences of Air Pollution. Cambridge, MA, Ballinger, 1976.

_____ and Timothy A. Deyak. Measuring the Impact of Air Pollution on Property Values. Journal of Regional Science 15:277-288, 1975.

Spence, James W., Fred H. Haynie and J.B. Upham. Effects of Gaseous Pollutants on Paints: A Chamber Study. Journal of Paint Technology 47:57-63, 1975.

Spinka, J. Effects of Polluted Air on Fruit Trees and Legumes. Zira 19:13-15, 1971.

Spore, Robert. Property Value Differentials as a Measure of the Economic Costs of Air Pollution. University Park, PA, Pennsylvania State University, Center for Air Environment Studies, 1972.

Sprugel, D.G., et al. Effect of Chronic Sulfur Dioxide Fumigation on Development of Yield and Seed Quality of Field-Grown Soybeans: A Summary of 1977 and 1978 Experiments, Annual Report, Radiology and Environmental Research Division. Argonne, IL, Argonne National Laboratory, 1978.

Standards for Fuel-Burning Sources: PM, SO_2, NO_2. n.d.

Steele, William. The Effect of Air Pollution on the Value of Single-Family Owner-Occupied Residential Property in Charleston, SC. Masters Thesis Clemson University, 1972.

Stern, Arthur C., et al. Fundamentals of Air Pollution. New York, Academic Press, 1973.

Switzer, Paul. Statistical Consideration in Network Design. Statistics and Environmental Factors in Health: Working Paper No. 10. Philadelphia, SIAM Institute for Mathematics and Society, August 1979.

Teknekron Research, Inc. Economic Impact of Water Pollution Control on the Steam-Electric Industry, prepared for the National Commission on Water Quality. Berkeley, CA, July 13, 1975.

Thibodeau, L.A. Assessing Air Pollution Control Benefits. n.d.

Thomas, M.D. and G.R. Hill. Relation of Sulfur Dioxide in the Atmosphere to Photosynthesis and Respiration of Alfalfa. Plant Physiology 12:309-383, 1937.

Tingey, D.T., et al. Chronic Ozone or Sulfur Dioxide Exposures or Both Affect the Early Vegetative Growth of Soybean. Canadian Journal of Plant Science 53:875-879, 1973.

_____. Foliar Injury Responses of 11 Plant Species to Ozone/Sulfur Dioxide Mixtures. Atmos. Environ. 2:201-208, 1973.

_____. Vegetation Injury from the Interaction of Nitrogen Dioxide and Sulfur Dioxide. Phytopathology 61:1506-1511, 1971.

Tombach, Ivar and Douglas Allard. Intercomparison of Visibility Measurement Methods, paper presented at the Air Pollution Control Association Specialty Conference on Visibility, Denver, November 27-28, 1979 in Journal of the Air Pollution Control Association 30:134-142, 1980.

Treshow, M. Environment and Plant Response. New York, McGraw-Hill Book Company, 1970.

TRW Systems Group. Demonstration of a Regional Air Pollution Cost/Benefit Model, (NTIS PB-202 345) prepared for the Air Pollution Control Office. McLean, VA, July 1971.

U.S. Environmental Protection Agency. Environmental Criteria & Assessment Office. Air Quality Criteria for Particulate Matter and Sulfur Oxides, Vol. 1 - Summary and Conclusions. (External Review Draft No. 1). Research Triangle Park, NC, April 1980.

_____. Air Quality Criteria for Particulate Matter and Sulfur Oxides, Vol. 2 - Air Quality. Research Triangle Park, NC, April 1980.

_____. Air Quality Criteria for Particulate Matter and Sulfur Oxides, Vol. 3 - Welfare Effects. Research Triangle Park, NC, April 1980.

_____. Air Quality Criteria for Particulate Matter and Sulfur Oxides, Vol. 4 - Health Effects. Research Triangle Park, NC, April 1980.

_____. Office of Air Quality Planning and Standards. Aeros Manual Series. Research Triangle Park, NC, February 1976. (Vol. 1: Aeros Overview; Vol. 2: Aeros User's Manual; Vol. 3: Summary and Retrieval; Vol 5: Aeros Manual of Codes; and Updates.)

_____. Air Quality Data, 1972-1977 Annual Statistics, 6 vols. Research Triangle Park, NC, 1973-1978.

_____. Directory of Air Quality Monitoring Sites Active in 1972-1977, 6 vols. Research Triangle Park, NC, 1973-1978.

_____. National Air Quality Levels and Trends in TSP and SO_2 Determined by Data in the National Air Surveillance Network. Research Triangle Park, NC, April 1973.

_____. Protecting Visibility: An EPA Report to Congress, (EPA-450/5-79-008). Research Triangle Park, NC, October 1979.

_____. Office of Research & Development. Addendum to 'The Health Consequences of Sulfur Oxides: A Report from CHESS, 1970-1971,' May 1974. (EPA-600/1-80-021). Washington, D.C., April 1980.

U.S. National Bureau of Standards. Economic Effects of Metallic Corrosion in the U.S. Part 1 - Report to the Congress (NBS Special Pub. 511-1) Washington, D.C., May 1978.

U.S. Occupational Health and Safety Administration. Office of Standards Development. Inflation Impact and Analysis of the Proposed Standard for Coke Oven Emissions, 29CFR1910.1029. Washington, D.C., February 27, 1976.

Urban Systems Research and Engineering, Inc. The Recreation Benefits of Water Quality Improvement: Analysis of Day Trips in an Urban Setting. Cambridge, MA, December 1, 1975.

Van Haut, H. Die Analyse von Schwefeldiorydwerkungen auf Planzen in Laboratoriumsversuch. Laboratory Experiments on the Effects of SO_2 on Plants. Staub 21:52-56, 1961.

Vars, Charles R. and Gary W. Sorenson. Study of the Economic Effects of Changes in Air Quality. Corvallis, OR, Oregon State University, Air Resources Center, June 1972.

Waddell, Thomas E. The Economic Damages of Air Pollution. Research Triangle Park, NC, U.S. Environmental Protection Agency, Office of Research and Development, May 1974.

Watson, William D. and John A. Jaksch. Air Pollution: Household Soiling and Consumer Welfare Losses, unpublished paper, April 1980.

Webster, C.C. The Effects of Air Pollution on Plants and Soil. London, Agricultural Research Council, 1967.

Weinstein, L.H., et al. Effect of Sulfur Dioxide on the Incidence and Severity of Bean Rust and Early Blight of Tomato. Environmental Pollution 9:145-155, 1975.

Whittemore, Alice. Mathematical Models of Cancer and Their Use in Risk Assessment. Statistics and Environmental Factors in Health: Technical Report No. 27. Philadelphia, SIAM Institute for Mathematics and Society, August 1979.

_____. Air Pollution and Respiratory Disease. Statistics and Environmental Factors in Health: Technical Report No. 38. New Canaan, CT. SIAM Institute for Mathematics and Society, July 1980.

Wieand, Kenneth F. Air Pollution and Property Values: A Study of the St. Louis Area. Journal of Regional Science 13:91-95, 1973.

Williams, M.D., E. Treiman and M. Wecksung. Plume Blight Visibility Modeling with a Simulated Photograph Technique, paper presented at the Air Pollution Control Association Specialty Conference on Visibility, Denver, November 27-28, 1979 in Journal of the Air Pollution Control Association 30:131-134, 1980.

Williamson, Samuel J. Fundamentals of Air Pollution. Reading, MA, Addison-Wesley, 1973.

Woodcock, Kenneth R. A Model for Regional Air Pollution Cost/Benefit Analysis, prepared for the Air Pollution Control Office (NTIS PB-202 353). McLean, VA, TRW Systems Group, May 1971.

Zerbe, Robert, Jr. The Economics of Air Pollution: A Cost Benefit Approach. Toronto, Ontario Department of Public Health, 1969.

Zimmerman, P.W. and W. Crocker. Toxicity of Air Containing Sulfur Dioxide Gas. Contrib. Boyce Thompson Inst. 6:445-470, 1954.